S. Hrg. 100-470

# GEOTHERMAL STEAM ACT AMENDMENTS OF 1987

## HEARING

BEFORE THE

SUBCOMMITTEE ON MINERAL RESOURCES
DEVELOPMENT AND PRODUCTION

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

ONE HUNDREDTH CONGRESS

FIRST SESSION

ON

## S. 1006

GEOTHERMAL STEAM ACT AMENDMENTS OF 1987

JULY 14, 1987

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J. Bennett Johnston and James A. McClure are Ex Officio Members of the Subcommittee
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# GEOTHERMAL STEAM ACT AMENDMENTS OF 1987

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TUESDAY, JULY 14, 1987

U.S. Senate,
Subcommittee on Mineral Resources
Development and Production,
Committee on Energy and Natural Resources,
*Washington, DC.*

The subcommittee met, pursuant to notice, at 10:28 a.m., in room SD-366, Dirksen Senate Office Building, Hon. John Melcher, presiding.

## OPENING STATEMENT OF HON. JOHN MELCHER, A U.S. SENATOR FROM THE STATE OF MONTANA

Senator **Melcher**. The subcommittee will come to order. This morning we are proceeding with testimony on S. 1006, a bill introduced by Senator Hecht, which provides among other things for the extension of geothermal leases on Federal lands.

Geothermal energy is an important component in achieving this Nation's energy security. The U.S. Geological Survey estimates that it has identified recoverable geothermal energy which could be readily used to generate electricity in about 440 quadrillion BTUs, equivalent to about 40 billion barrels of oil.

However, there are concerns regarding the impact of geothermal development and significant geothermal features with national parks and monuments. As important as geothermal energy is, we cannot allow it to be developed at the expense of nationally significant features, such as Old Faithful, the geyser basin in Yellowstone National Park.

In accordance with Public Law No. 99-591, the Department has recently issued a list of significant thermal features within national parks to be protected against adverse impacts of geothermal leasing.

I hope to hear from witnesses today as to the adequacy of the list. I am also aware there are some concerns that geothermal development on private lands may be affecting thermal features within the parks.

Especially with regard to that, we will have testifying today owners who have developed a hot water well very close to Yellowstone Park. We have asked them to testify today to provide us with the facts as to how and under what circumstances that well was drilled.

I will also be expecting to hear from the Park Service and USGS on the determination on whether development that close, within miles of the park, a few scant miles of the park, has no impact, no possible impact on the geyser basin in Yellowstone National Park.

Others have been asked to testify, that will enlighten us, and provide the hearing record on just what we need to do and how significant it is to safely develop geothermal energy in other areas.

[The text of S. 1006 follow:]

100TH CONGRESS
1ST SESSION

# S. 1006

Entitled the "Geothermal Steam Act Amendments of 1987".

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## IN THE SENATE OF THE UNITED STATES

APRIL 9 (legislative day, MARCH 30), 1987

Mr. HECHT (for himself, Mr. INOUYE, Mr. MCCLURE, Mr. GARN, Mr. MATSUNAGA, Mr. STEVENS, Mr. MURKOWSKI, Mr. NICKLES, Mr. SYMMS, and Mr. HATCH) introduced the following bill; which was read twice and referred to the Committee on Energy and Natural Resources

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# A BILL

Entitled the "Geothermal Steam Act Amendments of 1987".

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

SECTION 1. This Act may be known as the "Geothermal Steam Act Amendments of 1987".

SEC. 2. The following subsection is inserted at the end of section 2 of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1001):

"(f) 'Substantial investment' means expenditures made on one or more of the following: drilling exploratory, development, or temperature gradient wells; geological, geochemical, or geophysical surveys; environmental studies; architectural and engineering services procured in connection with design of generating facilities; or other expenditures approved by the Secretary.

SEC. 3. Section 6 of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1005(a)) is amended by striking subsection (a), and inserting in lieu thereof, the following:

"(a) Geothermal leases shall be for a primary term of ten years. If geothermal steam is produced or utilized in commercial quantities on a lease, or under an approved cooperative or unit plan of development or operation, as governed by section 18 of this Act, in which a lease is included within this term, or any administrative extension thereof as provided under subsection (c), such lease shall continue for so long thereafter as geothermal steam is produced or utilized in commercial quantities, but such continuation shall not exceed an additional forty years.".

Sec. 4. Subsection 6(c) of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1005(c)) is amended by renumbering the current language as paragraph 6(c)(1), and by inserting the following as a new paragraph 6(c)(2):

"(c)(2) Any geothermal lease issued pursuant to this Act and in effect on or after the date of enactment of the Geothermal Steam Act Amendments of 1987, shall be extended for successive five-year periods, but totaling not more than fifteen years, if—

(i) the lessee has submitted a report to the Secretary detailing bona fide efforts to bring such lease or approval cooperative or unit plan of development into commercial production, given the then current economic conditions; and either

(ii) actual drilling operations, to a depth specified by the Secretary, were commenced prior to the end of its primary term and prior to the end of each successive five-year extension period on such lease or on another lease sharing a common geothermal resource and where at least one party has an interest in both leases; or

(iii) in the opinion of the Secretary, substantial investment has been made during the primary term and during each successive five-year extension on such lease or on another lease sharing a common geothermal resource and where at least one party has an interest in both leases;

SEC. 5. Section 6 of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1005(d)) is amended by striking subsection 6(d), and inserting in lieu thereof the following:

"(d) For purposes of subsection (a) of this section, the term "produced or utilized in commercial quantities" includes the completion of a well capable of producing geothermal steam in paying quantities."

SEC. 6. Section 18 of the Geothermal Steam Act of 1970 as amended (30 U.S.C. 1017) is amended by inserting the following new paragraph after the first full paragraph of that section:

"Five years approval of any cooperative or unit plan of development or operation, and every five years thereafter, the Secretary shall review each such plan and, after notice and opportunity for comment, eliminate from inclusion in such plan any lease or part of a lease not regarded as reasonably necessary to cooperative or unit operations under the plan: *Provided,* That such elimination is based on scientific evidence, and occurs only when it is determined by the Secretary to be for the purpose of conserving and properly managing the geothermal resource. Any lease or part of a lease so eliminated would be eligible for an extension under section 6(c) of this title if it separately meets the requirements for such an extension.".

SEC. 7. Section 115(2)(d) of Public Law 99-500 is amended by inserting the words ", extended, or renewed" after the word "issued".

Senator MELCHER. Senator Hecht.

## STATEMENT OF HON. CHIC HECHT, A U.S. SENATOR FROM THE STATE OF NEVADA

Senator HECHT. Thank you, Mr. Chairman. I would like to thank you for holding this hearing today on S. 1006, the Geothermal Steam Act Amendments of 1987.

This bill has strong support here in this committee and bipartisan support in the full Senate. I am also very pleased that Congressmen Matsui and Coelho have introduced a companion measure, H.R. 2794.

I understand the House Interior Committee is planning to hold a hearing on that companion bill sometime in the near future.

Geothermal energy is a clean, small-scale form of energy that is easy on the environment and easy on the ratepayers' pocketbooks. It is renewable and decreases our reliance on foreign energy sources.

Although geothermal energy development has experienced great technical challenges and recently experienced difficult market conditions, the President's recent report on energy security indicates that geothermal energy production could double by 1995.

This means it could become a truly significant energy source, particularly in the western part of our country. However, if geothermal energy is to realize its potential, the companies involved need the incentives provided under this legislation.

Without this legislation, geothermal energy will be dealt a serious setback from which it may take many years to recover.

I believe, Mr. Chairman, with your assistance and active participation, that we can get this bill enacted into law during this Congress.

I would like to thank you once again for your interest in geothermal energy and this bill. I look forward to hearing our witnesses today, and I look forward to working with you on this legislation.

I ask that the testimony of the Hon. Robert T. Matsui, Member of Congress, Sacramento, CA, be included in the record.

[The prepared statements of Senators Johnston, Metzenbaum, Hatfield, and Congressman Matsui follow:]

SUBCOMMITTEE ON MINERAL RESOURCES DEVELOPMENT AND PRODUCTION

HEARING ON S. 1006

July 14, 1987

Statement for Senator J. Bennett Johnston

The hearing today is a good opportunity to look closely at the issues associated with the development of geothermal resources. The development of geothermal energy for this country is important and should not be held hostage to the fluctuating energy market. While all energy markets are currently depressed, there will come a time when we will need all of our energy sources -- oil, gas, and coal, as well as geothermal and other less traditional sources -- to meet this nation's energy needs.

We can not, however, rush head-long into the development of geothermal energy without carefully evaluating the impacts of its development.

I am very interested in the Department's implementation of Pub. L. No. 99-591, requiring the Secretary to designate significant thermal features within the National Park System. I believe it is extremely important that our nationally significant thermal features are protected from adverse impacts from geothermal leasing.

## STATEMENT BY SENATOR HOWARD M. METZENBAUM

I continue to be very concerned about the impact of geothermal leasing on our national parks. While I am pleased that the Department of Interior has finally issued a list of significant thermal features within the National Park System, pursuant to the park protection stipulations enacted into law last year, I will closely monitor further implementation of this new program.

Of immediate concern will be the process used by the Department to determine whether or not geothermal activity on a lease is likely to adversely affect a park feature, as well as the precise nature of protective stipulations written into new leases where such a likelihood exists.

Also of concern are the procedures to be followed when new lease applications are made before adequate information has been gathered about the likely effects of activity on such leases. It is my hope that the Department will not proceed in the issuance of leases and development permits while information is inadequate for making an accurate determination.

Finally, the effectiveness of this program will be largely dependant on the general monitoring program established by the Department to assess the effects of ongoing geothermal development on park features. The level of scrutiny and thoroughness devoted to this monitoring program will largely determine the program's effectiveness.

I look forward to following this program's development and implementation by the Department, in order to insure that the irreplacable and magnificent geothermal features in our National Park System are protected for the enjoyment of generations to come. I will appreciate being informed by the Department of any specific measures adopted for the program's implementation.

SENATOR MARK O. HATFIELD
QUESTIONS FOR THE RECORD
COMMITTEE ON ENERGY & NATURAL RESOURCES
S. 1006, GEOTHERMAL STEAM ACT AMENDMENTS
JULY 14, 1987

With regard to Section 115 of the Department of Interior and Related Agencies Appropriations Act for 1987 (PL 99-591), it is my understanding that the Department of the Interior has concluded that there is insufficient information available to make a determination on a possible thermal feature at Crater Lake National Park in Oregon.

* Is the Department considering further study this summer and fall on Crater Lake to make a determination concerning a thermal feature? If so, when will the Department conclude its study and make a final determination?

* Will geothermal development activities be allowed to continue on the federal lands outside the boundaries of the park while the study is in progresss? If so, please identify those activities. Will new leases be issued while the study continues?

* Can you tell me how many leases have been issued to date on the federal land surrounding the boundary of the park and how many acres of land are involved? Please identify those companies currently holding those leases and how many acres are controlled by those companies. What are the expiration dates of the leases?

* How many geothermal wells or test holes have been drilled on the current leases? What are the dimensions and depths of those wells or test holes? How many drilling permits have been issued to date on those lands? How many applications for drilling permits have been filed?

* Please describe the Department's policies with regard to the monitoring of the developmental activities on the current leases.

* In addition to this summer's study, it is my understanding that the Park Service will embark upon a four year study of Crater Lake. How will that study differ from this summer's study? Are the two studies related? What type of geothermal activities will be allowed while the four year study is in progress? Will any new leases be issued while the four year study is in progress?

* Please explain the Department's intentions with regard to the conclusion of this summer's study of Crater Lake. Will the Department make a conclusive decision this fall, or will it defer the decision until the completion of the four year study? If the decision is deferred, will the policies concerning geothermal development and leasing change or remain the same?

* What studies are being planned to investigate the effects that geothermal development taking place several miles from the park boundaries may have on Crater Lake? In effect, if drilling is being planned on federal land that is seven or eight miles from the park boundaries, will the proposed studies be able to determine the impact that such activites will have on the park itself?

TESTIMONY OF THE
HONORABLE ROBERT T. MATSUI
MEMBER OF CONGRESS
SACRAMENTO, CALIFORNIA

GEOTHERMAL STEAM ACT OF 1987

JULY 14, 1987

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON MINERAL RESOURCES DEVELOPMENT AND PRODUCTION

Mr. Chairman, distinguished Members of the Subcommittee, good morning, I appreciate the opportunity to address to you the Geothermal Steam Act of 1970. As you may know, I have introduced a similar measure in the House to accompany Senator Chic Hecht's bill.

Our bill simply amends the Geothermal Steam Act of 1970 to allow companies that hold geothermal leases to retain those leases where temporary market conditions preclude power plant construction.

Specifically, the bill would allow the Secretary of the Interior to issue up to three consecutive five-year extensions if the lessee performs according to diligence requirments specified by the Secretary. It also follows through on a landmark provision incorporated into the FY 1987 Continuing Resolution that solved the longstanding problem of how to protect thermal features in our national parks without imposing "buffer zones" around the parks.

Geothermal energy development is characterized by large front-end development costs, risky power plant technology, and diligence requirments on federal leases that are ore stringent than the equivalent requirments for oil and gas leases. The current temporary glut in the world energy market and the temporary surplus in U.S. electrical power generating capacity, together threaten to undo much of the progress made by the

Geothermal Energy industry over the last fifteen years.

Mr. Chairman, it would be very unwise for us to allow this to happen. Geothermal energy is renewable, it is clean, it reduces our need for foreign energy imports, and it protects our electric ratepayers from "rate-shock" because by its very nature it tends to be added to the rate base in relatively small increments of about 150 megawatts or less.

The National Energy Security study which was recently released by the administration points out that geothermal energy now contributes about 2,000 megawatts of electricity in the United States, but that this could double by 1995. We have a real opportunity through this legislation to assist this renewable energy industry in meeting that goal.

Mr. Chairman, our bill will encourage the nation's geothermal energy industry to hang on through the difficult times that are facing the entire renewable energy industry. If you support renewable energy initiatives and see a need to encourage the domestic energy industry and to reduce the vulnerability of America's energy supply to foreign interference, then you will want to join us in supporting this legislation.

Senator **Melcher**. Thank you very much.

Our first witness this morning is Mr. Robert Lawton, Assistant Director for Energy and Minerals, Bureau of Land Management, Department of the Interior. Is F. Eugene Hester, Associate Director for Natural Resources, National Park Service, accompanying you while you testify today?

## STATEMENT OF ROBERT H. LAWTON, ASSISTANT DIRECTOR, ENERGY AND MINERAL RESOURCES, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR, ACCOMPANIED BY F. EUGENE HESTER, ASSOCIATE DIRECTOR FOR NATURAL RESOURCES, NATIONAL PARK SERVICE

Mr. **Lawton**. We have submitted our testimony for the record.

Senator **Melcher**. Please proceed.

Mr. **Lawton**. Thank you, Mr. Chairman. I appreciate this opportunity to appear today before the subcommittee to discuss the Department of the Interior's position on S. 1006.

Mr. Chairman, we support enactment of S. 1006. The existing Act only allows lease extension by production or a well capable of production and a signed contract for delivery of production within 15 years.

S. 1006 would eliminate the requirement that there be a contract for delivery or utilization. We support this change for two reasons.

First, because of the current oversupply of electrical generating capacity, it is difficult to market production at any price. And second, lessees are at a distinct disadvantage when sales contracts are negotiated with a short time constraint.

This amendment would eliminate the lease termination problems. Without some modification, we anticipate continued relinquishment of existing leases and little demand for new leasing.

Recent experience, in fact, indicates that the uncertainty of provisions of leases has likely led to relinquishments of leases and only limited interest in new leases.

As an example, in 1982 there was a total of 1,892 leases outstanding, whereas today we only have 853 active leases. And of these, about 99 are protected by the 2-year extension provision under the Appropriations Act or held by production.

Also, in 1982 we issued 418 leases. One hundred and seventy-two of these were by competitive bidding and brought in $23.5 million in bonuses. During that year, we only had 159 relinquishments.

During 1983 and 1984, only 416 leases were issued. But 928 were surrendered. In 1985, the pattern continued and we only issued 69 new leases. But 233 were relinquished. In 1986 activity appeared to stabilize to the point that 144 new leases were issued against 148 surrenders.

For the first nine months of fiscal year 1987, we had no new leasing due to the leasing moratorium. But, during this period, we had 369 relinquishments. This experience would indicate the need for removing uncertainty and ensuring a method of holding a lease through dedicated attempts to develop a very important energy resource.

S. 1006 should provide that opportunity for serious developers to achieve production. The public interest is well served by keeping leases in the hands of lessees who have sizable investments in leaseholds and have strong incentives to establish production.

There is one provision in S. 1006 that we believe should be reexamined. We believe the bill should be modified to clear up an apparent inconsistency in language between section 3 and section 6, in that section 6 would amend section 18 of the act to direct that leases be eliminated from units if they are no longer necessary to unit operation, while section 3 would amend section 6(a) to protect leases from expiration if they are within a producing unit or one that is capable of production.

Mr. Chairman, this concludes my remarks, and we will be open for questions.

[The prepared statement of Mr. Lawton follows:]

JUL 1 4 1987

**STATEMENT OF ROBERT H. LAWTON, DEPUTY ASSISTANT DIRECTOR, ENERGY AND MINERAL RESOURCES, BUREAU OF LAND MANAGEMENT, DEPARTMENT OF THE INTERIOR, BEFORE THE SUBCOMMITTEE ON NATURAL RESOURCES DEVELOPMENT AND PRODUCTION, COMMITTEE ON ENERGY AND NATURAL RESOURCES, UNITED STATES SENATE, ON S. 1006, A BILL "ENTITLED 'THE GEOTHERMAL STEAM ACT AMENDMENTS OF 1987'".**

I appreciate the opportunity to appear before the Subcommittee today to discuss the Department of the Interior's position on S. 1006.

S. 1006 would be cited as the "Geothermal Steam Act Amendments of 1987."

Section 2 of S. 1006 would define "substantial investment" as expenditures for well-drilling, geological, geochemical, and geophysical surveys, environmental studies, architectural and engineering services used in designing generating facilities, and other expenditures approved by the Secretary.

Sections 3, 4, and 5 of S. 1006 would amend sections 6(a), (c), and (d) of the Geothermal Steam Act of 1970 to provide that if geothermal steam is produced or utilized in commercial quantities on a lease or under an approved cooperative or unit plan of development or operation in which a lease is included within the 10 year primary term or any administrative extension thereof, the lease would continue for as long as geothermal steam is produced or utilized in commercial quantities. The continuation could not exceed an additional 40 years. A geothermal lease in effect on or after the date of enactment of S. 1006 would be extended for successive 5-year periods, for a total of not more than 15 years, if the lessee has submitted a report detailing bona fide efforts to bring the lease into commercial production, and either (1) commenced drilling operations to a depth specified by the Secretary prior to the end of the primary term and each 5-year extension period on such lease or another lease sharing a common geothermal resource, or (2), in the opinion of the Secretary, made substantial investment, as defined in section 2, during the primary lease term and each extension on such lease or another lease sharing a common geothermal resource. When the drilling or investment occurs on another lease, at least one party would be required to have an interest in both leases.

Section 6 of S. 1006 would amend section 18 of the Geothermal Steam Act by adding a new paragraph requiring that 5 years after approval of any cooperative or unit plan of development or operation, and every 5 years thereafter, the Secretary must review each plan and, after notice and opportunity for comment, eliminate from inclusion in such plan any lease or part of a lease not regarded as reasonably necessary to cooperative or unit operations under the plan. Such elimination would have to be based on scientific evidence, and be for the purpose of conserving and properly managing the geothermal resource. A lease or part of a lease so eliminated would be eligible for extension if it separately met the requirements for extension.

Section 7 of S. 1006 would require the Secretary to include stipulations protecting significant thermal features in all lease extensions and renewals as well as in all new leases.

We support enactment of S. 1006.

The Geothermal Steam Act presently allows a geothermal lease to continue beyond its 10-year primary term in only two situations: either the lease must be producing, or there must be both a well capable of production and a sales contract for delivery or utilization of the shut-in production, with utilization scheduled to commence within 15 years of the effective date of the lease. S. 1006 would eliminate the requirement that there be a contract for delivery or utilization.

We support this change for two reasons. First, with the current oversupply of electrical generating capacity, it is difficult for Federal geothermal lessees to market their production at any price. Second, Federal lessees are at a disadvantage when sales contracts are negotiated inasmuch as they operate under a time constraint. If the lessees do not execute contracts, regardless of how unfavorable the terms may be, they may lose their leases. The amendment would eliminate the lease termination problem when a contract cannot be made within 15 years. Without this change, we anticipate that in the near future there will be many relinquishments of existing leases and little demand for new ones.

S. 1006 also would liberalize the conditions under which geothermal leases could be extended. Currently, a lease can be extended only once, and only if actual drilling operations are being diligently pursued at the time expiration would otherwise occur. S. 1006 would allow up to three successive 5-year extensions provided either that drilling had commenced to a depth specified by the Secretary, or that substantial expenditures had been made. As a result, serious developers will be rewarded with additional time to make discoveries. The public interest is well served by keeping leases in the hands of lessees who have already sunk costs in leaseholds and would have strong incentive to establish production.

We also believe the bill should be modified to clear up one apparent inconsistency in language between section 3 and section 6, in that section 6 would amend section 18 of the Act to direct that leases be eliminated from units if they are no longer necessary for unit operations, while section 3 would amend section 6(a) to protect leases from expiration if they are within a producing unit or one that is capable of production. We suggest that this apparent inconsistency be clarified by adding to section 18 the statement that leases may be eliminated notwithstanding the provisions of 6(a).

We also suggest one technical amendment. Section 2 of the bill should be amended by changing the word "means" to "includes" in the new paragraph (f) to be added to section 2 of the Geothermal Steam Act of 1970. As written, the paragraph would not define "substantial", but would merely list expenditures to be considered, and section 4 of the bill, in paragraph (c)(2)(iii), would make it clear that the Secretary of the Interior decides whether the investment is substantial.

This concludes my statement. I will be pleased to answer questions.

Senator MELCHER. Who is in charge of enforcing Public Law No. 99-190?

Let us see, there is Public Law 98-473, and Public Law No. 99-190, and then Public Law No. 591, having to do with leasing around the park areas.

Mr. LAWTON. Mr. Chairman, the Bureau of Land Management has the responsibility for issuing leases and doing their accompanying NEPA compliance and other activities, leading to the issuing of leases and monitoring of drilling and production and abandonment.

Senator MELCHER. Does that answer the question, or is that just part of the answer?

Mr. LAWTON. I think it answers the question you asked. Who is responsible for leasing around the parks.

Now for the work that is done in preparing for leasing, there is coordination with other agencies, be they surface management agencies and other parties of interest.

The public, private, State, all these have inputs into the decision process we go through in our planning the work that is done in preparing for issuance of leases. There is coordination with all these other agencies.

The Bureau has the responsibility for the actual issuance of the leases.

Senator MELCHER. Chapter 23, dealing with geothermal steam and associated geothermal resources says, in part, the Secretary of Interior shall publish for public comment in the Federal Register within 120 days after date of enactment—that was last year, October of last year—a proposed list of significant thermal features within the following units.

And then it lists a whole bunch of national parks. Who does that for the Secretary of the Interior?

Mr. LAWTON. That procedure was carried out by the National Park Service and the Bureau of Land Management within the Department.

That report has been submitted by the Secretary, and I believe all of you have received it.

Senator MELCHER. You say that is jointly BLM and the Park Service?

Mr. LAWTON. That is correct, sir.

Senator MELCHER. And the Secretary shall include with such lists the basis for its determination with respect to each thermal feature on the list.

That is also jointly shared?

Mr. LAWTON. This was done by the people within the Department. Yes, National Park Service and BLM participated.

Senator MELCHER. BLM and the National Park Service. Are we ever going to get to the USGS? Are they involved with this?

Mr. LAWTON. They are involved. They have worked and provided information on the scientific side.

Senator MELCHER. Well, how involved are they?

Mr. LAWTON. They participated throughout, providing information in the deliberations on each individual site.

Senator MELCHER. Were they involved in, Mr. Hester, were they involved at Yellowstone?

Mr. HESTER. Yes, sir. They were.

Senator MELCHER. Is the well on private land, on the Royal Teton Ranch, part of that involvement?

Mr. HESTER. Sir, I would have to ask Mr. Donald Click, who is here from the Geological Survey, as to their participation in that particular issue. May I do so?

Senator MELCHER. Who is it?

Mr. HESTER. Mr. Donald Click from the Geological Survey.

Senator MELCHER. Would you come to the witness table, Mr. Click?

Mr. CLICK. Yes, the Geological Survey worked with BLM and the National Park Service in preparing the entire report and in helping review the words, the terminology, that we used to define significant thermal features.

Yellowstone National Park as an entire entity was placed on the list. The point being, of course, to place additional requirements upon the leasing program in areas surrounding parks that have significant thermal features listed.

Senator MELCHER. I did not hear you. Pull the microphone closer please.

Mr. CLICK. I said, the Geological Survey was concerned and involved with the National Park Service and BLM throughout the whole activity, coming up with the report.

Yellowstone National Park was included as an entire entity. The purpose being, of course, to place additional requirements upon a geothermal leasing program to take a closer look at the leasing applications that were close by to units of the park that had significant thermal features listed.

To my knowledge, there are not any lease applications around Yellowstone. BLM would have to address that.

Senator MELCHER. My question went directly to the point of the well at Royal Teton Ranch. Were you involved in reviewing that and whether that had any significance?

Mr. CLICK. Not during the activity to prepare the report, we were aware of it.

And if there were lease applications for Federal lands around that area, there would be no doubt that that would come under the requirements of the leasing program under section 115. The BLM would have to comment on that.

Senator MELCHER. Then you are not aware of the letter of May 10th of this year from the Superintendent of Yellowstone that draws the conclusion that it is our view that the plans to develop a geothermal well, as outlined in the Hydrometrics report, which is the report prepared for the Royal Teton Ranch, that the planned development of that geothermal well would pose an unacceptable risk for geothermal features in Yellowstone National Park?

Mr. CLICK. What we are aware of is the existence of a well that is drilled about 450 feet near LaDuke Hot Spring zone on private land, and the intended purposes of the well being for what is commonly called direct heat use—heating swimming pools, heat in buildings, and that sort of thing, and not for electrical power generation.

Senator MELCHER. You are aware of the well?

Mr. CLICK. Yes.

Senator MELCHER. But you are not aware of this letter?

**Mr. Click.** No, I am not.

**Senator Melcher.** Are any of the three of you aware of this letter?

**Mr. Hester.** I am aware that the Superintendent of Yellowstone National Park has expressed his concern to the officials of the church.

**Senator Melcher.** Has expressed his concern?

**Mr. Hester.** Yes.

**Senator Melcher.** That is the Superintendent of the national park speaking for himself, and is he speaking for the Department of the Interior?

**Mr. Hester.** He has the authority to speak as it relates to Yellowstone National Park on that issue.

**Senator Melcher.** Is his letter the position of the Department of the Interior or not?

**Mr. Hester.** It has not been endorsed by the Secretary, if that is your question, nor have we asked the Secretary whether he would endorse the letter.

**Senator Melcher.** What is going to happen? Nothing?

**Mr. Hester.** Right now the issue rests with the State of Montana.

**Senator Melcher.** Why the State of Montana?

**Mr. Hester.** Because it is privately owned land in Montana, and the question there is one of a well as opposed to development of a geothermal resource.

**Senator Melcher.** Let us see. Yellowstone National Park is owned by whom?

**Mr. Hester.** By the U.S. Government.

**Senator Melcher.** By the people of the United States.

**Mr. Hester.** That is correct.

**Senator Melcher.** So the position is going to be to do nothing unless the State of Montana does something about the whole thing?

**Mr. Hester.** The State of Montana has the responsibility and right, as I understand it, to rule on this issue.

**Senator Melcher.** On what basis do you have that understanding?

**Mr. Hester.** The basis of water rights and State law.

**Senator Melcher.** Water rights? Well, I am from Montana. I know of no State law that says that we have got something on the statute books that says we are going to protect Old Faithful.

Do you know of any such statute?

**Mr. Hester.** That is not the basis on which it is made.

**Senator Melcher.** On what basis would we protect Old Faithful? On the basis of the State of Montana doing something?

**Mr. Hester.** The only other basis that I am aware of is the possible use of the Organic Act of the National Park Service, or of the act——

**Senator Melcher.** Federal law.

**Mr. Hester.** Or the act establishing Yellowstone National Park.

**Senator Melcher.** That is Federal law, is it not?

**Mr. Hester.** That is correct.

**Senator Melcher.** Where would that come from? The Department of Interior, the State of Montana?

Mr. **Hester**. That would eventually come from the Interior Department.

Senator **Melcher**. And we are well aware, I think maybe more so you are aware of the fact that, of the unique geothermal operations. These grand geothermal features of the world have been destroyed simply by drilling wells. Have they not?

Mr. **Hester**. It potentially could happen.

Senator **Melcher**. As I read that law, was not the Secretary supposed to give us some advice along in this report on protecting those geothermal features?

Mr. **Hester**. Yes.

Senator **Melcher**. Well, Yellowstone is, it is my understanding that Yellowstone, with Old Faithful, the geyser basin there, is the world's outstanding geyser basin. Is that correct?

Mr. **Hester**. That is correct.

Senator **Melcher**. I think, Mr. Hester and Mr. Lawton, you better be telling the Secretary of the Interior that there is some concern, first of all, by Barbee, the Superintendent of Yellowstone, that this particular well is significant and may damage Old Faithful and the geyser basin in Yellowstone, and get some report up here, some advice up here, on whether or not you think you have adequate law and what you would recommend be done about it.

And do it pronto, because if we are going to do anything we are going to do it right on this bill that we are holding this hearing on this morning. Thank you.

Senator Hecht.

Senator **Hecht**. Thank you, Mr. Chairman. I will be very brief. Mr. Lawton has said he is in favor of the bill with a few technical changes, and I am an old retailer. Once you make a sale you shut up. So I have just asked Scott, my staff man, he said the changes do not really change the bill that significantly.

Just two real short questions, though. Can you lose a lease if you have made significant expenditures? And what procedure is followed by the Department of Interior after a leaseholder loses a lease because time has expired?

Mr. **Lawton**. In answer to your first question, the primary term of a geothermal lease is 10 years. That lease can only be held beyond 10 years in two ways—if they are in production, or, as I mentioned in the statement, if you have a well capable of producing and a contract for delivery within 15 years.

Another way is to be drilling over that exploration period. If one of these conditions is not met, there is nothing to hold that lease beyond the primary term, regardless of the amount of money expended.

And I think this is one of the problems that has bothered people in going ahead with a geothermal program. Ten years is a short period to really get into production and everything completed.

Senator **Hecht**. Plus the massive capital outlays.

Mr. **Lawton**. Exactly. And the risk that is involved of losing this lease. And I think this has prevented people from getting really active in the geothermal area.

Senator **Hecht**. Will the Federal Government gain revenues by allowing leases to expire and then reopening them under a competitive bid process?

Mr. LAWTON. That is a difficult question. Our position is no.

I would think that for anyone who has obtained a lease, they obtained a lease for a specific purpose. They want to develop geothermal resources. They have put money into it by competitive bidding up front.

They have paid a bonus. They have maintained the lease through diligence. They have probably put money in that lease by the end of the 10th year. They have more of an incentive to go ahead and produce from that lease because of their sunk costs.

Geothermal leasing is what I would classify a reactive process within the Federal Government. That means we do not force anybody to take a lease. We cannot force anybody to take a lease.

If they come in and want a lease, then we react to that application and the land can be leased noncompetitive or competitive. We go through a very comprehensive planning process to determine if leases should be issued, and what stipulations to place in those leases to protect against whatever problems may arise.

So I think the short answer to your question is, we would prefer to see lands remain in the hands of people who do hold them, and who have made expenditures. There is no way of even knowing if somebody would pick up a lease once it is terminated.

Senator HECHT. Thank you very much. Mr. Chairman, I want to reiterate what I have said to you the last 4 years.

Any changes that you might want to make to protect Yellowstone, we are certainly amenable to it and we will work with you on it.

Senator MELCHER. I thank you very much, Senator Hecht. Thank you all very much.

We will call our next witness, Mr. Edward L. Francis, Vice President and Business Manager of Royal Teton Ranch, Livingston, MT.

Mr. Francis, we have your prepared testimony with the accompanying documents. And we are going to make it part of the record. And if you will please summarize your testimony, we would appreciate it.

## STATEMENT OF EDWARD L. FRANCIS, VICE PRESIDENT AND BUSINESS MANAGER, CHURCH UNIVERSAL AND TRIUMPHANT, ROYAL TETON RANCH

Mr. FRANCIS. I will try to be as brief as I can, sir. Mr. Chairman and Members of the subcommittee, I wish to thank you for giving me the opportunity to come up here and give my testimony today.

The church first purchased its property in Montana, named it the Royal Teton Ranch. In 1981 this property was purchased from publisher Malcolm Forbes, and a short time thereafter we acquired some additional property adjacent to the ranch on the east side of the Yellowstone River at the hamlet of Corwin Springs.

Corwin Springs today just consists of a post office and a restaurant, but early in the 20th century it featured a 72-room grand hotel and resort and other facilities there, all of which was heated from the waters of LaDuke Hot Spring, which is about 1½ miles to the south.

The town's main attraction was the hot spring. It was also supported by several other towns that existed there in the early part of the 20th century, known as Aldridge and Electric.

These towns had several thousand residents and they were located on what is today the Royal Teton Ranch, that is owned by the church. The towns eventually declined—they were coal-mining towns—because of the rising use of petroleum.

And Corwin Springs eventually declined because of that and because of the fire when the hotel burned down, although the hot water remained in use there until well after World War II.

There was a wooden pipeline that transported the water from the LaDuke Springs to Corwin Springs, and that pipeline has now fallen into disrepair and is no longer serviceable. When we first purchased the property, we became the owner of virtually all the water rights to LaDuke Hot Spring.

These rights were first appropriated for use in 1899, which actually predates the expansion of Yellowstone Park into Montana by more than 30 years. These water rights remain basically unchallenged today.

They have been filed, preliminary decrees have been issued in the adjudication process in Montana, and the two main rights. They have the recreational rights here, and for commercial use we are not challenged by any other Federal Government agency, although a time period was allowed.

Since 1981 when we purchased the property various methods have been studied to install a new pipeline to convey the water from LaDuke Spring to the town. But it was determined that this would not be feasible because of the limitations of the terrain.

A particularly attractive alternative, however, was to use the water directly across the river from LaDuke Hot Spring on the ranch, which would be a distance of only several hundred feet.

According to Montana water law, a permit from the State can be obtained to change the point of diversion and the place of use for an existing water right. And to that end we drilled the exploratory well in 1986, only 728 feet from the actual discharge of LaDuke Hot Spring.

That well was drilled through a hard clay formation to a total depth of 458 feet, with the hot water first encountered at about 400 feet. And since that time it has pretty much been capped, except for some brief periods of testing.

In July, the church unexpectedly sold its headquarters in California, and we decided to re-establish them on the ranch. And a site was picked right next to the previous town site of Electric that had about 1,000 residents back in 1910.

And we decided to further investigate the use of the well at that location. To that end, we hired the firm of Hydrometrics, a well-respected hydrological firm in Montana.

Concurrently with that study the State of Montana has been conducting an EIS of its own on the relocation of the church headquarters there, and has been taking a look at the possible impacts of the well on the geothermal features of Yellowstone.

The first phase of the study of Hydrometrics primarily included an aquifer test. Also, some review of the existing literature available concerning the Corwin Springs area, in particular as related to Yellowstone Park.

The results of these investigations were issued in a report dated December 23, 1986. And according to that report the aquifer tests showed conclusively that the aquifer penetrated by the well also is the source of water for LaDuke Hot Spring.

The importance of this data was to establish clearly that the church's thermal well involves the use of an existing natural discharge to LaDuke Hot Spring that has historical commercial uses to which the church owns the water rights, and a new and previously unused geothermal water source is not involved.

On the subject of potential impacts to Yellowstone geothermal features, the study was less definitive, primarily because of the lack of hydrogeological knowledge about the park's geothermal systems.

However, on the basis of published geological studies and several technical considerations that were identified by the consultant, indicated that there should be no impact to park resources from pumping the well at the historical levels of spring discharge.

Now, at the time that the report was prepared, he estimated that historical level of discharge to be in the range of 400 to 500 gallons per minute. And the report's conclusions were conditioned on that level of use.

What is important to realize is that we have never proposed or intended to use any more water from our well than the naturally occurring discharge of LaDuke Hot Spring to which it is directly connected, whatever the actual level of that natural discharge might turn out to be.

If 500 gallons per minute does not turn out to be the actual figure, but instead a lower one is more accurate, then the lower one would be chosen as our upper limit. The hydrologic principle here is that if no more than the naturally occurring discharge is withdrawn, there cannot be any result to the aquifer.

It would be a physical impossibility. What is still being looked at is the mechanics of how this can be accurately quantified and accomplished.

We set this forth in a letter to Robert Barbee, the Superintendent of Yellowstone Park in January 1987, and we stated to him in that letter that we have no plans to undertake any further geothermal drilling in the area in the future.

If any damages to the geothermal features occur, which are attributable to our well, we would stop pumping or reduce the usage. Additional light was shed on this subject by Mr. John Sonderegger of the Montana Bureau of Mines and Geology, who has also prepared a report.

He prepared this at the behest of the State, who was conducting the EIS. He states that the question of whether Mammoth Hot Springs in Yellowstone Park is hydrologically connected to LaDuke Hot Spring cannot be definitely answered.

However, he does postulate how the various geothermal discharges could represent one large system. And I would point out that this is in disagreement with the geological interpretation mapped by at least four other individuals who have studied the systems before and upon which our own consultant's analysis was based.

Sonderegger's report also raises the question about the accuracy of the 500 gallon per minute USGS measurement, which was made in 1972. Also, which our consultant's report was based on.

While much of the postulating about unknown geology and hydrology and past flow measurements is inconclusive on everyone's part, the report's real value would appear to be contained in its best case-worst case analysis.

The best case analysis supports the conclusion of our hydrologist, which is that there is no hydrologic connection between LaDuke Springs and the systems inside the park, and that therefore there would be no impact.

The worst case is that a hydrologic connection does exist, and that continued use at 400 to 500 gallons per minute could possibly cause some of the Mammoth Springs to have an impact.

Now, that is based primarily on the fact that the 400 to 500 gallons per minute could be larger than the naturally occurring discharge, because that has been drawn into question.

However, assuming the worst case scenario to be true, his analysis offers the way of preventing any such impacts, while still allowing use of the well. He states that limitations could be placed upon production at LaDuke by requiring that pumpage be adjusted such that the original point of diversion to LaDuke Hot Spring maintains a small but measurable flow.

Limiting withdrawals from the existing well to the yield, which does not quite dry up the LaDuke Springs, is particularly appealing because of its simplicity. It would require periodic sampling to verify that the spring is still yielding.

But it is a simple way to insure that excessive pressure reductions, due to pumping, do not occur. Now this is one of the chief geologists in the State of Montana.

In the next development, Yellowstone National Park issued its comments, to which you have already referred. And they were commenting on the Hydrometrics report. They did not incidentally comment on the Sonderegger report, but the Montana Bureau of Mines and Geology.

They too questioned the 1972 500 gallon per minute measurement, and on that point Superintendent Barbee's letter concludes that the issue of the spring's output is one of the most critical factors to be determined.

In light of Superintendent Barbee's well-taken point, and in order to gather data on natural discharges occurring at LaDuke Hot Spring to determine what level of pumping could safely be sustained from the wells and stay within Sonderegger's guidelines, further testing of the spring was undertaken in June of 1987 by our consultant.

From that it appears that the naturally occurring discharge from LaDuke Hot Spring is in the range of at least 130 to 220 gallons per minute, as previously measured and recorded. Plus there are additional flows occurring in a zone around the main spring reservoir and under the Yellowstone River.

It is important to state at this point that we are still in the investigation and research stage on this project, and we do not anticipate moving forward, at least until the EIS being conducted by the state is concluded.

Though thousands of dollars have been spent in studying the well and spring, we have not yet even applied for a permit to change the point of diversion and the place of use and to begin using the well.

That process will likely take up to a year to complete. Until that process is concluded and a permit issued, no substantial use can be made of the hot spring water at the well other than necessary testing.

Due to all of the uncertainties outlined above, no firm decisions have been reached by us and no definite plans have been made concerning the ultimate uses of this water. I have been asked by your staff what the uses would be, however.

They said you would be interested in this. And essentially, our general plans at this time would be the heating, first the heating of one to three buildings, but certainly not all of the buildings planned for construction at the proposed headquarters there.

Only a small fraction of the planned buildings could conceivably be heated from 138 degree Fahrenheit water, such as flows from the spring and the well, supplied at 200 gallons per minute, which is what the flow will likely turn out to be.

After the water has been partially cooled from heating buildings, it can then be used to heat a hot spring pool and health spa that would not call for any additional withdrawal from the aquifer.

Greenhouse heating or other agricultural applications might follow the building heat. Or the cool use. Again, this would involved the same water previously used and now new water would need to be withdrawn from the aquifer.

Implementation of these projects will probably take place over a 2- to 5-year period. And we have no further plans beyond this. And certainly no further plans for any other geothermal production or development.

We realize that the subject of geothermal development around the Nation's national parks, and particularly around Yellowstone, is an extremely emotional one. No one would want to witness, let alone be responsible for, as you have said, the drying up of Old Faithful or any other geysers or natural wonders of Yellowstone.

We are in total agreement on this. But like all other important national issues of our time, these questions must be addressed with as much factual analysis and scientific data as possible. Not just with emotion and rhetoric.

Our thermal well project is quite different from the type of activity covered by S. 1006, and has to be distinguished from it. The Federal leasing program envisions commercial exploration, renewed geothermal sources, and large-scale development for power generation.

Our well involves changing the point of diversion of a naturally occurring hot spring discharge of relatively small proportions in order to heat several buildings and a pool, all of it covered by existing and historically used water rights.

However, while I have no opinion to offer on the bill, I do have some observations to offer that could be relative to this process.

We have noticed a tendency on the part of the National Park Service to automatically oppose development or new uses of Federal or private lands near parks, sometimes even when the impacts are either unknown or before they are ascertained.

This creates problems for the agencies and private landowners involved, as it already has for us. And when discovered, it is neither a good scientific position nor a credible stand to take in the eyes of much of the public.

There is a difference between protecting and managing park resources for the benefit and enjoyment of people, as the National Park Service is charged to do, and in viewing additional human activity as a priori incompatible with the park's purpose.

The latter is a more radical position, not accepted by most of the American people, in my opinion. Unfortunately, I believe that an overemphasis on opposing development outside the national parks has led the Park Service to take inconsistent or illogical positions, in some cases, not based upon knowledge of the resource, but on a lack of it.

In our case, for example, Yellowstone Park has strongly opposed the location of our church headquarters, which I have described to you, on our own private land over 2 miles outside of park boundaries before even waiting for the results of the state's EIS to come out.

This despite the fact that we have proposed to use less than 1 percent of our land for a church, school, or anything else other than open space and agriculture.

In doing so, the park takes the inconsistent position of saying the settlement of 500 persons or less in an agriculturally-based religious community outside of the park is unacceptable, but that several million annual visitors and a half dozen towns inside the park, which are many times the size of the church community, are OK.

Now what will the park then say if the EIS comes out and contradicts the position they have already taken. This is certainly also the case on the issue of new geothermal exploration and development.

If they have watched the issue develop around Yellowstone, it may be, in fact, that unacceptable impacts could occur to park resources if this activity were allowed. But there are qualified scientists willing to say, and who have said right now, that there will be little or no impact.

Yellowstone Park officials have expressed grave reservations. But their apprehension seems to be based more on examples of what has gone wrong in other parts of the world than on any particular knowledge about the hydrogeology of Yellowstone and surrounding areas.

This is not a very defensible position. The danger here is that next year, or 20 years from now, new and different Government personnel will decide that this is not good enough and will go ahead and allow the development anyway.

While it may be considered a dangerous risk today, it may not be viewed as such in the future. We, therefore, believe it is incumbent on the National Park Service and the Department of the Interior to resolve this issue with appropriate research and evaluation, using available scientific means.

And we would also urge that Congress aid in this process by providing appropriate direction and funding for a study. In order to make sure that the results are completely unbiased, we also believe it would be appropriate to assign this task to an independent agency possessing the expertise, with no particular vested interest in the area being studied, such as the USGS.

Mr. Chairman, this concludes my testimony for today. I wish to thank you for this opportunity and I would be happy to answer any questions at this time.

[The prepared statement and attachments submitted by Mr. Francis follow:]

# TESTIMONY TO BE GIVEN JULY 14, 1987
by Edward L. Francis of
CHURCH UNIVERSAL AND TRIUMPHANT
to
SENATE SUBCOMMITTEE ON MINERAL
RESOURCE DEVELOPMENT AND PRODUCTION

Mr. Chairman and Members of the Subcommittee, I wish to thank you for giving me the opportunity to give my testimony today.

My name is Edward L. Francis and I reside in Corwin Springs, Montana. I am the Vice President and Business Manager of Church Universal and Triumphant and have been for the last twelve years. The Church is the owner of a sizeable ranch near the northern boundary of Yellowstone National Park--known as the Royal Teton Ranch. I have been the resident manager there for six years.

In connection with your consideration of S.1006, the "Geothermal Steam Act Amendments of 1987," Senator Melcher has invited me to give testimony to the Subcommittee on the subject of a geothermal project being planned by the Church on that property.

The Church first purchased the Royal Teton Ranch, located on the west side of the Yellowstone River 7 miles north of the gateway community of Gardiner, from publisher and financier Malcolm Forbes in September 1981. A short time thereafter we acquired some additional property adjacent to the ranch on the east side of the river at the hamlet of Corwin Springs.

Today Corwin Springs consists of a post office and a restaurant, but early in the 20th century it featured a 72-room hotel and resort accommodating over a hundred guests, a dance hall where big bands entertained local residents, Yellowstone Park employees and visitors, a health spa and hot spring pool (or "plunge" as it was commonly known in those days), and at one time even a golf course along the banks of the Yellowstone River--all of it heated from the waters of LaDuke Hot Spring located about one and a half miles to the south. (See attached map and historical information.)

Its main attraction was the hot spring water, but its existence was also heavily supported by two other local communities that prospered during the first two decades of the 20th Century. The coal mining towns of Aldridge and Electric covered large parts of what is now the Royal Teton Ranch, and combined, contained almost two thousand residents at their height. By 1909 a bridge was built across the Yellowstone linking the communities with Corwin Springs two miles to the north.

With the decline of coal and the rise of petroleum's fortunes, these towns eventually faded and died. That, coupled with a tragic fire that destroyed the huge hotel, resulted in the eventual decline of Corwin Springs--although the hot spring pool was restored and remained open to the public until well after World War II. However, the old wooden pipeline from LaDuke Hot Spring has fallen into disrepair and is no longer serviceable.

When the Church purchased the Corwin Springs property, it became the owner of virtually all of the water rights to the Hot Spring. These rights had first been appropriated for use in 1899--predating the expansion of Yellowstone Park into Montana by more than 30 years. And, pursuant to the water rights adjudication process currently taking place in Montana, timely filings were made for all of these existing rights--including claims for prior uses of hot water for commercial, irrigation, domestic and recreational purposes. These include a total of 11.6 cubic feet per second (cfs) which have now been preliminarily decreed by the Water Court.

Under the adjudication law, any claimants, including state and federal agencies, are allowed a certain period of time to file objections after the publication of the preliminary decree by the Water Court for each drainage basin. While some of the claims on LaDuke Hot Spring were objected to by government agencies, the two primary commercial use claims with the earliest priority dates--totaling 5.0 cfs, or approximately 2,250 gallons per minute (gpm)--were not objected to at all. These water rights therefore stand unchallenged.

Since 1981, various methods have been studied to reinstall a new pipeline to convey the LaDuke Hot Spring water to the Corwin Springs developments. It has appeared that such a project would not only be costly, but also unsightly and disruptive, since the terrain across which the pipeline would be laid is a fairly steep and narrow strip between mountain slopes and the Yellowstone River--most of which is now occupied by an expanded U.S. Highway 89 that did not exist when the original pipeline was laid.

However, a particularly attractive alternative that came to light was the possibility of using the hot spring water which currently discharges on Forest Service land on the east side of the Yellowstone River, directly across on the west side where our ranch is located. This is a distance of only several hundred feet to the place of use, versus a mile and a half down the river bank from LaDuke to Corwin Springs.

According to Montana Water Law, a permit from the state can be obtained to change the point of diversion and the place of use for an existing water right. To that end, we drilled an exploratory well in April 1986 on the west side of the Yellowstone River a total distance of 728 feet from the present LaDuke Hot Spring point of discharge to attempt to intercept the spring flow on the other side of the river. That effort turned out to be successful.

The well was drilled through a hard clay formation to a total depth of 458 feet, with the hot water first encountered at about 400 feet. Since the aquifer is confined at this point by the impervious clay above it, the static water level in the well casing came up to within 40 feet of the surface--or about the same elevation as the LaDuke Spring point of discharge across the river. The well was pump tested by the driller at 600 gpm for several hours to clean up the aquifer and to get a preliminary idea of its capacity, and then it was capped. Except for brief periods of testing it has remained capped to this date.

In July 1986, the Church unexpectedly sold its headquarters in California and decided to reestablish them in Montana on the Royal Teton Ranch. The site chosen for the new headquarters is right next to the previous townsite of Electric where upwards to a thousand people lived in 1910, and also only several hundred feet from the new well. We therefore decided to further investigate the possible use of the hot water in this area with a hydrological study and evaluation.

The firm of Hydrometrics was chosen as our consultant to perform this work. Hydrometrics is a well-known Helena, Montana firm headed by hydrologist Maxwell K. Botz. Mr. Botz is a Registered Professional Engineer in the State of Montana with a Bachelor's Degree in Geological Engineering and a Master's Degree in Water Resources Engineering. He was the former head of the Technical Investigations Section of the State Water Quality Bureau.

The purpose of this study as commissioned was:

(1) To investigate the possible connection between the well and the existing discharge at LaDuke Hot Spring, and to determine whether they should in fact be the subject of the same water rights; and

(2) To evaluate the potential for any adverse impacts to Yellowstone Park geothermal features from our use of the well.

Concurrently with that study, the State of Montana decided in the fall of 1986 to conduct an Environmental Impact Statement (EIS) on the Church's proposal to locate its headquarters on the ranch. The EIS is also making an examination of the LaDuke Hot Spring well and any possible impacts on Yellowstone National Park's geothermal features. This has included input not only from our own consultant, but from Yellowstone National Park and other federal and state agencies.

The first phase of the study by Hydrometrics included an "aquifer test" conducted on the well and the hot spring together. This involved taking temperature measurements, collecting water samples for lab analysis, pumping, and monitoring flows over an extended period. Also undertaken was a review of existing literature and scientific information available concerning LaDuke Hot Spring and the hydrogeological systems of Yellowstone Park.

The results of these investigations were issued in a report dated December 23, 1986. According to the report, the aquifer test showed conclusively that "...the aquifer penetrated by the thermal well also is the source of water for LaDuke Hot Spring." The factors cited for this conclusion were (1) very similar water quality as evidenced by laboratory analysis of samples taken from both the spring and the well, (2) identical water temperatures at 57°C (which converts to about 138°F), (3) a static water level in the well that is within five feet of the elevation of the spring point of discharge, and (4) a direct correlation between pumping of the well and the spring discharge (i.e., when the well was pumped spring flows declined, and when pumping stopped spring flows were soon restored).

The importance of this data was to establish clearly that the Church's thermal well involves the use of an existing natural discharge at LaDuke Hot Spring that has historical commercial uses to which the Church owns the water rights, and that a new and previously unused geothermal water source is not involved.

On the subject of potential impacts to any Yellowstone Park geothermal features, the study was less definitive primarily because of the lack of hydrogeological knowledge about the Park's geothermal systems. However, several technical considerations were identified by our consultant which indicated that there should be no impact to Park resources from pumping the well at the historical levels of spring discharge.

These included the large distance and difference in elevation from the nearest Park geothermal features (about 9 miles to Mammoth Hot Springs), the geologic diversity and lack of hydraulic continuity between the Park and the LaDuke Hot Spring area, and the fact that the discharge near Corwin Springs is significantly downgradient rather than upgradient from all of the Park features. (Several complete copies of the referenced report have been provided to the Subcommittee.)

At the time this report was prepared the historical level of discharge was estimated to be in the range of 400 to 500 gpm, and the report's conclusions were conditioned on this level of use. This estimate was based upon data obtained from the U.S. Geological Survey Water Resources Data for Montana which showed a measurement in 1972 of 500 gpm, which flow rate had been corroborated by the former owner who had made several private measurements. However, the accuracy of these measurements has since come into question, and some concern has been expressed that pumping at 500 gpm could in effect overuse the aquifer and, however unlikely, could cause some draining effect on Yellowstone geothermal systems should some unknown hydrological connection exist.

What is important to realize is that we have never proposed or intended to use any more water from our well than the naturally occurring discharge at LaDuke Hot Spring to which it is directly connected, whatever the actual level of that natural discharge might turn out to be. If 500 gpm does not turn out to be the actual figure but instead a lower one is more accurate, then the lower one would be chosen as our upper limit. The hydrologic principle here is that if no more than the naturally occurring discharge is withdrawn, there cannot be a resulting impact to the aquifer--it would be a physical impossibility. What is still being looked at is the mechanics of how this can be accurately quantified and accomplished.

In January 1987, our position was set forth in a letter to Yellowstone National Park Superintendent Robert D. Barbee, together with a copy of our consultant's report. In that letter I stated as follows:

> "I also wish to reiterate the substance of our former conversations and correspondence, wherein I have informed you that we have no plans to undertake any further geothermal drilling in the area in the future and that we have pledged that if any detrimental impacts on Park geothermal features occur which are attributable to our use of the well, we will stop pumping." (A copy of this letter is attached.)

Next, some additional light was shed on the subject with the issuance of another report prepared in March 1987 by John L. Sonderegger of the Montana Bureau of Mines and Geology. This report was prepared at the behest of two other state agencies involved in the Church's EIS. Sonderegger states that the question of whether Mammoth Hot Springs in Yellowstone Park is hydrologically connected to LaDuke Hot Spring cannot be definitely answered, however he postulates how the various geothermal discharges could represent one large system. This is in disagreement with the geological interpretation mapped by Struhsacker (1976), Ruppel (1972), Fraser and others (1969) relied upon by the Hydrometrics analysis.

Sonderegger's report also raises the question about the accuracy of the 500 gpm USGS measurement in 1972, pointing out that there are no measurement notes in the file to support that discharge value. The implication is that a lower figure in the range of 130-220 gpm, as documented by other USGS measurements, is likely more accurate. However, while much of the postulating about unknown geology, hydrology and past flow measurements is inconclusive on everyone's part, the report's real value would appear to be contained in its best case/worst case analysis.

The best case analysis assumes that LaDuke Hot Spring is hydrologically isolated from the Yellowstone Park/Mammoth Hot Spring systems and concludes that little or no impact would be noted in the Park from pumping the Church thermal well at 400 to 500 gpm. The worst case is that a hydrologic connection does exist and that continued use at 400 to 500 gpm could possibly cause some of the Mammoth Springs to cease flowing. But, assuming the worst case scenario to be true, his analysis offers a way of preventing any such impacts while still allowing the use of the well. The report states:

> "...limitations could be placed upon production at LaDuke, by requiring that pumpage be adjusted such that the original 'point of diversion,' LaDuke Hot Spring, maintains a small but measurable flow and that the chloride content of the thermal well water not exceed 50 Mg/L (a value 25% greater than that reported for the well). Limiting withdrawals from the existing well to the yield which does not quite dry up the LaDuke Spring is particularly appealing because of its simplicity. It would require periodic sampling to verify that the spring is still yielding geothermal water, but it is a simple way to insure that excessive pressure reductions due to pumping do not occur." (Several complete copies of the referenced report have been provided to the Subcommittee.)

In the next development, Yellowstone National Park issued comments in May 1987 on the Hydrometrics report which admits that LaDuke Hot Spring and the well drilled by the Church intercept the same aquifer, but also supports the "worst case" analysis postulated by Sonderegger that a hydrologic and/or geologic connection could exist between LaDuke Hot Spring and Yellowstone Park's geothermal systems. It too questions the 1972 500 gpm measurement. On that point, Yellowstone Superintendent Bob Barbee's letter concludes as follows:

> "In your letter and in other public statements you have said that as long as you did not pump more water than naturally flows from LaDuke Spring, the aquifer could not

be damaged. If we assume you were correct in that reasoning, then the issue of the spring's output becomes critical."

In light of Superintendent Barbee's well-taken point, and in order to gather data on actual discharges occurring at LaDuke Hot Spring and to begin to determine what level of pumping can safely be sustained from the well to stay within Sonderegger's guidelines, further testing of the spring was undertaken by Hydrometrics in June of 1987 for which a draft report has been prepared.

To begin with, in examining LaDuke Hot Spring it was noticed by the hydrologist that the discharge pipe at the north end of the spring reservoir had recently become plugged for unknown reasons, thus raising the water level by several feet and causing it to overflow and run off into the river by an alternate route than has previously been the case. This could have had the effect of raising the head in the spring box, thereby causing a restriction in the flow. To test this theory, the spring box was drawn down in several levels a total of about 22" with a siphon, and the resulting flows were measured. As expected, the discharge then increased from 64 gpm up to 115 gpm, with a predicted 150 gpm if drawn down another 14" to the level of the historically used discharge pipe. Additional points of discharge were also noted within a 100 x 1,000-foot zone around the spring and along and under the river banks. (Several complete copies of the referenced draft report have been provided to the Subcommittee.)

Thus, it appears that the naturally occurring discharge from LaDuke Hot Spring is in the range of at least 130-220 gpm as previously measured and reported, plus additional flows occurring in a zone around the main spring reservoir and under the Yellowstone River. Further testing of both the well and the spring will have to be performed to more precisely quantify the existing natural discharge before any definite magnitude of use can be planned for the water by the Church. It appears at this point, however, that the figure will be less than the 400-500 gpm previously estimated.

It is important to state that at this point we are still in the investigation and research stage on this project, and we do not anticipate moving forward at least until the EIS being conducted by the State of Montana is concluded. Though thousands of dollars have been spent in studying the well and spring, we have not yet even applied to the Montana Department of Natural Resources and Conservation for a permit to change the point of diversion and the place of use--a process that will itself involve further environmental evaluation, public hearings and input, and will likely take from six months to a year to complete.

Until that process is concluded, and a permit issued, no substantial use can be made of the hot spring water at the well other than necessary testing.

Due to all of the uncertainties outlined above, no firm decisions have been reached by us and no definite plans have been made concerning the ultimate uses of this water. We have only general plans and ideas at this time, and these include the following:

(1) Heating of one to three buildings, but certainly not of all of the buildings planned for construction at the Church's proposed headquarters location. This would best be accomplished by transferring heat to non-mineralized water in a sealed system through a heat exchanger and recirculating this heated water through concrete floor slabs. Only a small fraction of the planned buildings could conceivably be heated from 138°F water supplied at 200 gpm, if that's what the allowable flow turns out to be. And only a few of our buildings will have concrete slabs.

(2) After the water has been partially cooled to about 110°-125°F from heating buildings, it could then be used in a hot spring pool or health spa. This would not involve the withdrawal of any additional water from the aquifer, but would use the same water previously used for the building heat.

(3) Greenhouse heating or other agricultural applications might follow the building heat and/or pool use, probably at temperatures below 100°F. Again, this would involve the same water previously used and no new water would need to be withdrawn from the aquifer.

(4) Winter use would likely be much higher than summer use. And day use would likely be higher than night use. This could be evened out somewhat by constructing a storage reservoir similar to what is already in place at the present Hot Spring discharge site.

(5) Implementation of these projects would probably take place over a 2-5 year period. Beyond this, we have no further plans at this time, and certainly no plans for any further geothermal production.

We realize that the subject of geothermal development around the nation's national parks, and particularly around Yellowstone, is an extremely emotional one. No one would want to witness, let alone be responsible for, the drying up of Old Faithful--or any of the other geysers and natural wonders of Yellowstone. And we are in total agreement on this.

But like all other important national issues of our time, these questions must be addressed with as much factual analysis and scientific data as possible--not just with emotion and rhetoric.

On the subject currently being examined by this Subcommittee--whether to provide for the extension of geothermal leases on federal lands as allowed by S.1006--I have no strong opinions to offer.

Our thermal well project is quite different from the type of activity covered by this bill, and it is to be distinguished from it. The federal leasing program envisions commercial exploration for new geothermal sources and large-scale development for power generation. Our well involves changing the point of diversion for the use of a naturally occurring hot spring discharge of relatively small proportions in order to heat several buildings and a pool--all of it covered by existing and historically used water rights.

However, having now been involved in the geothermal issues around Yellowstone, I do have some observations to offer relative to S.1006.

We have noticed a tendency on the part of the National Park Service to automatically oppose developments or new uses of federal or private lands near parks, sometimes even when the impacts are unknown or before they are ascertained. This creates problems for the agencies and private landowners involved--as it already has for us--and, when discovered, it is neither a good scientific position nor a credible stand to take in the eyes of much of the public.

There is a difference between protecting and managing park resources for the benefit and enjoyment of the people, as the National Park Service is charged to do, and in viewing additional human activity as a priori incompatible with a park's purpose. The latter is a more radical position not accepted by most of the American people.

Unfortunately, I believe that an overemphasis on opposing development outside the national parks has led the Park Service to take inconsistent or illogical positions--in some cases not based upon knowledge of the resource, but on a lack of it. In our case, for example, Yellowstone Park has strongly opposed the location of our Church headquarters which I've described to you, on our own private land over two miles outside of Park boundaries, before even waiting for the results of the state's EIS to come out--this despite the fact that we propose to use less than 1% of our land for church, school or anything else other than open space and agriculture.

In doing so, the Park takes the inconsistent position of saying that a settlement of 500 persons in an agriculturally based religious community outside of the Park is unacceptable, but that several million annual visitors and a half-dozen towns inside the Park which are many times the size of the Church community are okay. And what will the Park then say if the EIS comes out and contradicts the position they have already taken?

This is certainly also the case on the issue of new geothermal exploration and development as I have watched the issue develop around Yellowstone. It may be that unacceptable impacts could occur to Park resources if this activity were allowed. But there are qualified scientists willing to say right now that there will be little or no impact--such as in the case of the Island Park Geothermal Area EIS issued in 1980.

Yellowstone Park officials have expressed grave reservations, but their apprehension seems to be based more on examples of what has gone wrong in other parts of the world than on any particular knowledge about the hydrogeology of Yellowstone and surrounding areas. This is not a very defensible position. The danger here is that next year or twenty years from now, new and different government personnel will decide that this isn't good enough and will go ahead and allow the development anyway. While it may be considered a dangerous risk today, it may not be viewed as such in the future.

We therefore believe it is incumbent upon the National Park Service and Department of the Interior to resolve this issue with appropriate research and evaluation using available scientific means. And we would also urge that Congress aid in this process by providing appropriate direction and funding for a study. In order to make sure that the results are completely unbiased, we also believe it would be appropriate to assign this task to an independent agency possessing the expertise and with no vested interest in the particular area being studied--such as the U.S.G.S.

This concludes my testimony for today. I wish to again give my appreciation to Senator Melcher and to the members of this Subcommittee for giving me the opportunity to express my views on this important subject. Thank you very much.

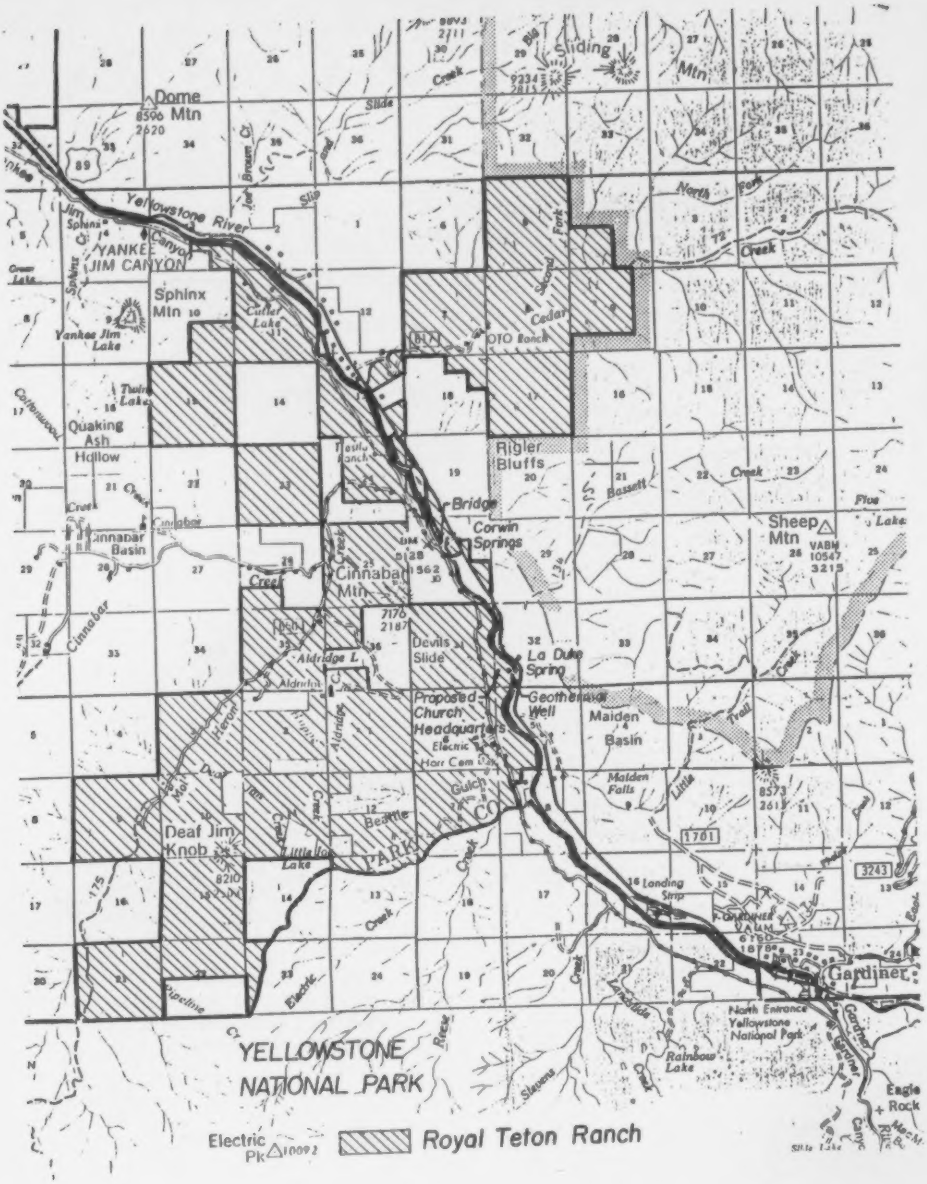
ATTACHMENTS TO TESTIMONY OF EDWARD L. FRANCIS OF CHURCH UNIVERSAL AND TRIUMPHANT, TO BE GIVEN JULY 14, 1987 TO SENATE SUBCOMMITTEE ON MINERAL RESOURCE DEVELOPMENT AND PRODUCTION

1. Map of Royal Teton Ranch and Corwin Springs Area.
2. Historical Information relating to Corwin Hot Springs Hotel and Plunge.
3. Letter from Edward L. Francis of ROYAL TETON RANCH to Robert D. Barbee, Superintendent of YELLOWSTONE NATIONAL PARK, dated January 15, 1987.

* * * * *

THREE COPIES OF EACH OF THE FOLLOWING REPORTS HAVE BEEN PROVIDED TO THE SUBCOMMITTEE FOR ADDITIONAL REFERENCE PURPOSES:

1. Report by HYDROMETRICS of Helena, Montana, entitled "AQUIFER TESTING AND EVALUATION OF A GEOTHERMAL WELL AT ROYAL TETON RANCH NEAR CORWIN SPRINGS, MONTANA," dated December 23, 1986. (Appendix 5 includes Abstracts of Water Rights to LaDuke Springs.)
2. "Informal Report to State of Montana Agencies - Department of Health and Environmental Sciences, and Department of Natural Resources and Conservation - Concerning Potential Effects of Production from a Geothermal Well Located Near La Duke Hot Spring," by John L. Sonderegger of MONTANA BUREAU OF MINES AND GEOLOGY, March 1987.
3. DRAFT Report by HYDROMETRICS of Helena, Montana, entitled "WATER PRODUCTION TESTS OF LA DUKE HOT SPRING, PARK COUNTY, MONTANA," dated June 1987.


Dome Mtn
Sliding Mtn
Yellowstone River
YANKEE JIM CANYON
Sphinx Mtn
Yankee Jim Lake
Cutler Lake
OTO Ranch
North Fork Creek
Second Fork
Cedar Creek
Twin Lakes
Quaking Ash Hollow
Rigler Bluffs
Bridge
Corwin Springs
Sheep Mtn
Cinnabar Basin
Cinnabar Mtn
Devils Slide
Aldridge L
La Duke Spring
Geothermal Well
Proposed Church Headquarters
Maiden Basin
Maiden Falls
Deaf Jim Knob
Beattie Gulch
Little Trail Creek
Landing Strip
Gardiner
North Entrance Yellowstone National Park
Rainbow Lake
Eagle Rock
YELLOWSTONE NATIONAL PARK
Electric Pk
▨ Royal Teton Ranch

Royal Teton Ranch NEWS

July 4, 1983

The original 1909 Corwin Springs Hotel and Plunge that burned down in 1916 was one of three "health and pleasure resorts" in Park County, according to the December 1916 *Livingston Enterprise*, and was "located in one of the scenic spots of the world." The complex was built on what is now called the East Gate, an 8 acre parcel acquired by Royal Teton Ranch last summer.

# CORWIN SPRINGS:
## Past, Present, and Future

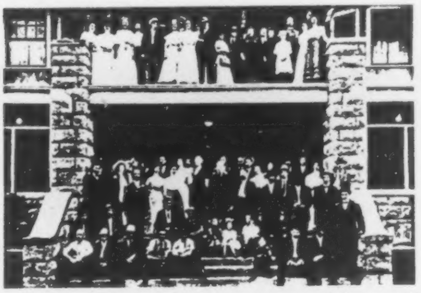
*A MILE* down the road from The Ranch Kitchen toward Yellowstone National Park, a Forest Service sign marks the location of La Duke Springs, a natural geothermal spring claimed as far back as the turn of the century to have unsurpassed medicinal properties.

The local historians Bill and Doris Whithorn record that in 1901, visitors from Aldridge, Cinnabar, Jardine, and other nearby communities including Horr (Electric) and the coal camps across the Yellowstone, came every Sunday to the La Duke hot springs to relax in the healthful waters.

In 1902, Julius La Duke and his family built a big new plunge at the springs—a large pool fed by a hot spring for mineral baths and swimming. The La Dukes operated a hotel and, since there was no bridge across the Yellowstone River, they installed a ferry and a cable-car crossing and later a suspension footbridge. The La Duke family moved up the mountain to the mining town of Aldridge in 1905. The plunge was managed by Albert La Duke until 1907 and by the Chapman family from 1908 to 1912.

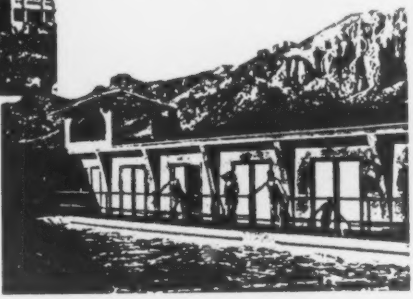
In 1908, the Electric Hotel Company began construction of a resort hotel and sanitarium a mile and a half from La Duke at the present East Gate entrance to the Royal Teton Ranch. The $100,000 chateau-style building (pictured above) was completed in 1909, along with the present bridge that replaced the old cable-car crossing still found north of the bridge today.

Hot water that flows directly out of the mountain at La Duke Springs was piped for the first time more than a mile to Corwin Springs for the original plunge. This was an earlier version of the Spanish-style, fortlike plunge structure that is still at the East Gate. Dr. F. E. Corwin, resident medical doctor at nearby Chico Hot Springs, was called in 1908 to be in charge of the health and pleasure resort soon known by his name.



Old-timers at Corwin Springs Hotel. The main attraction is the congenial Dr. and Mrs. Corwin (1st and 3rd from right on balcony). Corwin was hired in 1908 to plan the resort and was the physician in charge until 1912, just long enough to lend his name.

This Spanish-style plunge, a rebuilt version of the 1909 plunge that reopened on the same location in 1928, was part of Western land developer Walter J. Hill's Eagle Nest Ranch that extended 10 miles north from Yellowstone Park to Yankee Jim Canyon, the same boundary as Royal Teton Ranch.



The Whithorns record that the town of Gardiner was practically depopulated on Saturdays by the activity at the new Corwin Hot Springs. Conventions and many social events including exciting swimming and athletic contests and local dances were held at the indoor plunge and hotel.

In their *Photo History of Aldridge*, the Whithorns wrote that the seventy-two-room resort boasted "a beautiful lawn and grounds, electric lights all around so that tourists passing by on the Park Branch [railroad] would think they had passed through fairyland, and sidewalks adorning the main street." For $2.50 per day, a day's wage at the local mines, visitors were treated to rooms with hot and cold running water, telephones, steam heat, and electric lights.

On Thanksgiving Day in 1916, an early-morning fire leveled the fine resort which was never rebuilt to its original proportions. Local gossip has it that the disgruntled wife of a gambler who spent too much time at the hotel set the place on fire, though she was never brought to trial.

Following the fire, the property was sold by the owner, Mr. Hefferlin of Merchant's Bank in Livingston, to the Sidebotham brothers who built the open-air plunge, now a relic of an era gone by at Corwin Springs. This second plunge was opened to the public in April of 1922.

The Sidebothams later sold the property to Walter J. Hill, son of the empire building railroad baron James J. Hill, and the plunge was reopened in 1928. Hill created a sportsman's paradise for Eastern businessmen by adding a clubhouse, golf course, and cabins "providing every kind of diversion desired by the tired businessman on his holiday." Hill, who boasted knowing "every inch of the great Northwest," considered Corwin "the pick of the Western country," "a country of boundless beauty, unsurpassed anywhere in America."

Royal Teton Ranch now owns the plunge at Corwin Springs and the water rights to La Duke hot springs, and plans to put them to good use in the near future.

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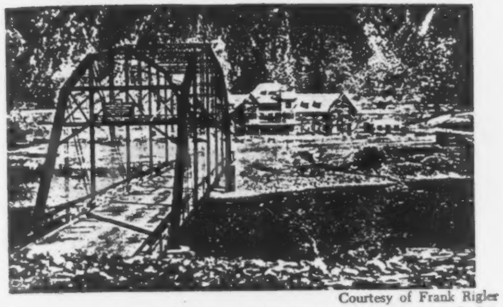


Courtesy of Frank Rigler

Construction at Corwin Springs, early 1909—Half the cost of this $13,500 county bridge was borne by the Electric Hot Springs Co., which was interested in building a 72-bed sanitarium. It was the first bridge built between Gardiner and Fridley.

Courtesy of Tony Koncilya

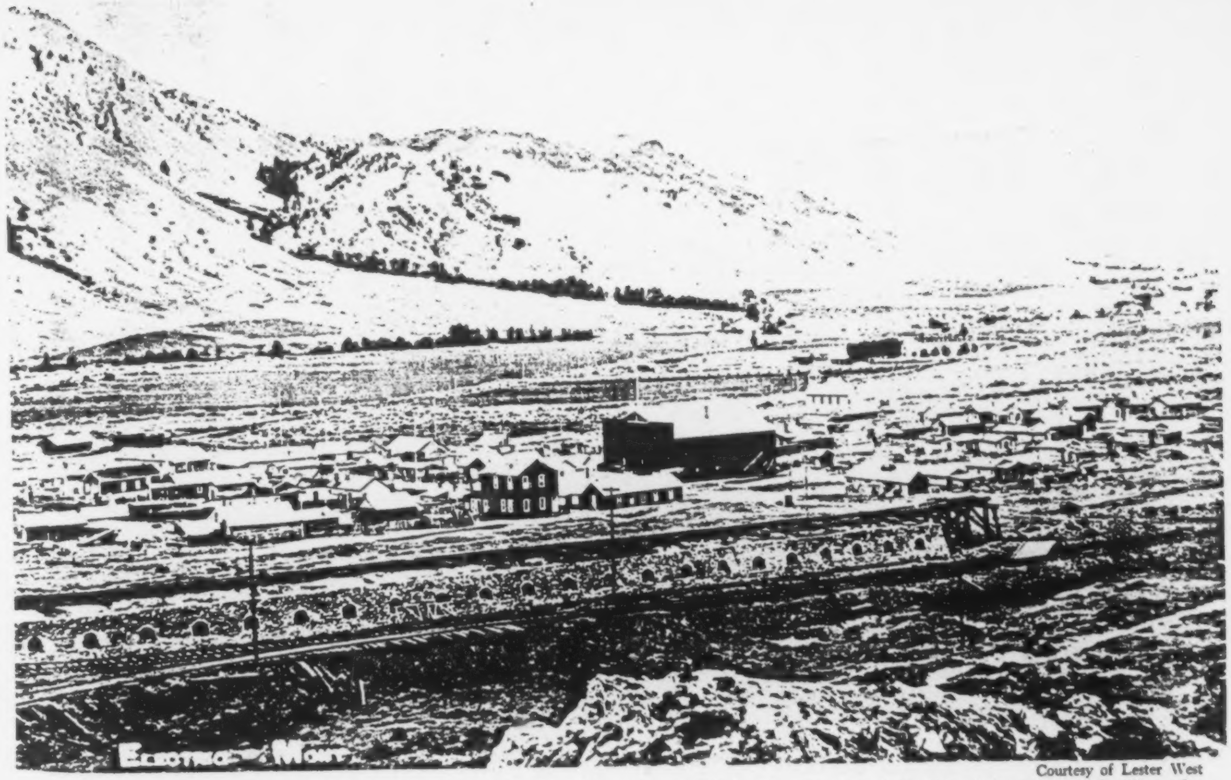
Corwin Hot Springs Hotel and Plunge—Opened in July 1909, this large sanatorium boasted electric lights, steam heat, hot and cold running water and telephones in each room for $2.50 per day.

Courtesy of Jim Bailey

Corwin Springs Hotel—Guests and members of the staff at the sanitarium appear on the front veranda of the resort. Doctor F. E. Corwin, for whom it was named, is third from the right on the upper balcony; Mrs. Corwin was at the far right. Among the maids in white are Lizzie Fodness, Myrtle Peterson and Grace Bailey.

Courtesy of Lina Nickelson

After the Fire—An early-morning fire on November 30, 1916, Thanksgiving morning, leveled the fine resort which, though operated with cabins and plunge in the '20s, never again was built to such proportions.



Courtesy of Lester West

Electric, Montana, after 1905—During the long, long strike The Company proceeded with expansion plans. One of those was the building of a very large store for the Montana Coal and Coke Trading Co. at Horr. It was completed in 1905. The name of the town of Horr became Electric during the summer of 1904.

Royal Teton
Ranch
Box A, Corwin Springs, Montana 59021 406/848-7381

January 15, 1987

Robert D. Barbee, Superintendent
YELLOWSTONE NATIONAL PARK
U.S. DEPARTMENT OF THE INTERIOR
P.O. Box 168
Yellowstone National Park, WY 82190

Re: Geothermal Well Study

Dear Bob,

As previously promised, I am enclosing for your review a copy of a study entitled "Aquifer Testing & Evaluation of a Geothermal Well at Royal Teton Ranch Near Corwin Springs, Montana." This report was prepared by Hydrologist Maxwell K. Botz of Hydrometrics Consulting Scientists and Engineers of Helena, Montana.

You will note that the report concludes that "the aquifer penetrated by the thermal well also is the source of water for LaDuke Hot Spring" (page 6), and that "there should be no impact from pumping the Royal Teton Ranch thermal well (at 400 to 500 gpm) on geothermal waters in Yellowstone National Park" (page 12). I am taking this opportunity to confirm for you that we do not intend to pump the well in excess of 500 gpm for any uses we might have.

I also wish to reiterate the substance of our former conversations and correspondence, wherein I have informed you that we have no plans to undertake any further geothermal drilling in the area in the future and that we have pledged that if any detrimental impacts on Park geothermal features occur which are attributable to our use of the well, we will stop pumping.

The Ranch Kitchen/Cinnabar Campground 406/848-7358
Engineering and Construction 406/848-7342

I will be interested in any further comments or suggestions you may have.

Very truly yours,

ROYAL TETON RANCH

Edward L. Francis
Vice President and Business Manager

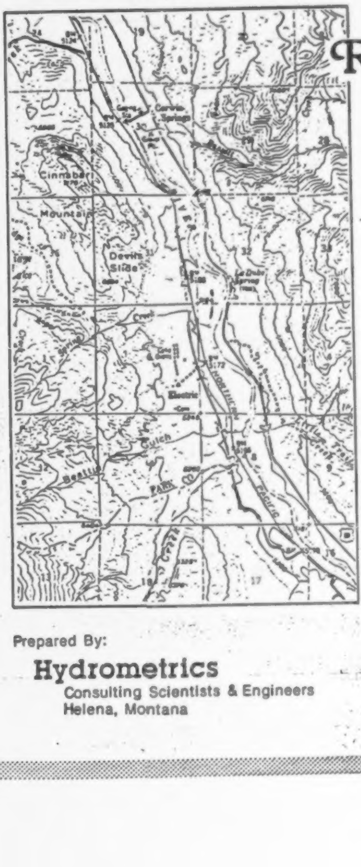
ELF:tcb

Enclosure

cc: Jim Melstad
WATER QUALITY BUREAU
DEPARTMENT OF HEALTH AND
ENVIRONMENTAL SCIENCES
Cogwell Building
Helena, MT 59620

Ted J. Doney, Esq.
P.O. Box 1185
Helena, MT 59624

# AQUIFER TESTING & EVALUATION OF A GEOTHERMAL WELL AT ROYAL TETON RANCH NEAR CORWIN SPRINGS, MONTANA


Corwin Springs
Cinnabar
Mountain
Devils Slide
Electric
Gulch
Park Co.

Royal Teton Ranch
Box A, Corwin Springs, Montana 59030 406/848-7381

MONTANA
Corwin Springs

Prepared By:

**Hydrometrics**
Consulting Scientists & Engineers
Helena, Montana

# AQUIFER TESTING AND EVALUATION OF A GEOTHERMAL WELL AT ROYAL TETON RANCH NEAR CORWIN SPRINGS, MONTANA

for

Mr. Edward L. Francis
Royal Teton Ranch
Box A
Corwin Springs, Montana 59021

by

HYDROMETRICS
2727 Airport Road
Helena, Montana 59601
406/443-4150

December 23, 1986

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APPENDIX 5. ABSTRACTS OF WATER RIGHTS TO THE LADUKE HOT SPRING

## SUMMARY

The following summarizes the pumping test and evaluation of a new geothermal well on the Royal Teton Ranch.

1. A thermal (hot water) well was drilled to a total depth of 458 feet and the well is located 728 feet from LaDuke Hot Spring and is across the Yellowstone River from the spring.
2. The thermal well was pumped for 13 hours at 400 gpm to measure drawdown, water quality and temperature and to determine the effects of pumping on flow of LaDuke Hot Spring. Pumping of the thermal well caused a rapid decrease in flow from LaDuke Hot Spring with flow declining from 52 to 4 gpm. Flow of the spring increased after pumping ceased.
3. Temperature and quality of LaDuke Hot Spring and the thermal well were nearly the same which indicates the same aquifer supplies both the spring and the well.
4. Hydrogeological knowledge of the region is insufficient to quantitatively predict the effect of pumping water from the thermal well on geothermal waters in Yellowstone National Park. Available hydrogeological information indicates the distance to Yellowstone National Park (10 miles), complex geological conditions and the discharge history of LaDuke Hot Spring makes it very unlikely that pumping of water from the thermal well at 400 to 500 gpm would have any impact on geothermal waters in Yellowstone National Park.

# AQUIFER TESTING AND EVALUATION OF A GEOTHERMAL WELL AT ROYAL TETON RANCH NEAR CORWIN SPRINGS, MONTANA

## INTRODUCTION

On April 17, 1986, a thermal (hot water) well was completed on the Royal Teton Ranch. The well is located 728 feet across the Yellowstone River from the LaDuke Hot Spring which is about 1.5 miles south of the community of Corwin Springs (Figure 1). The thermal well is 458 feet deep and the well drilling log is in Appendix 1. Royal Teton, Ltd. contracted for construction of the well in order to utilize its existing water rights from LaDuke Hot Spring. Historically, LaDuke Hot Spring was privately developed and the hot water was piped about a mile downstream along the east river bank for use at Corwin Springs. In 1909, a large hot spring resort at Corwin Springs was opened and water from LaDuke Hot Spring supplied the hot water through the pipeline to the resort. The hot water was used at the resort for many years. LaDuke Hot Spring now consists of a 75 foot long by five foot wide collection spring house. Water from the spring house is not currently used and overflow from the collection spring house is directed to the Yellowstone River via a culvert under Highway 87. The thermal well was constructed to allow water from the LaDuke Hot Spring to be used at a more convenient location across the Yellowstone River. Possible uses of this hot water by the Royal Teton Ranch include greenhouse heating, building heating and a hot pool.

Yellowstone National Park officials have voiced concern that pumping of the thermal well near LaDuke Hot Spring could impact geothermal

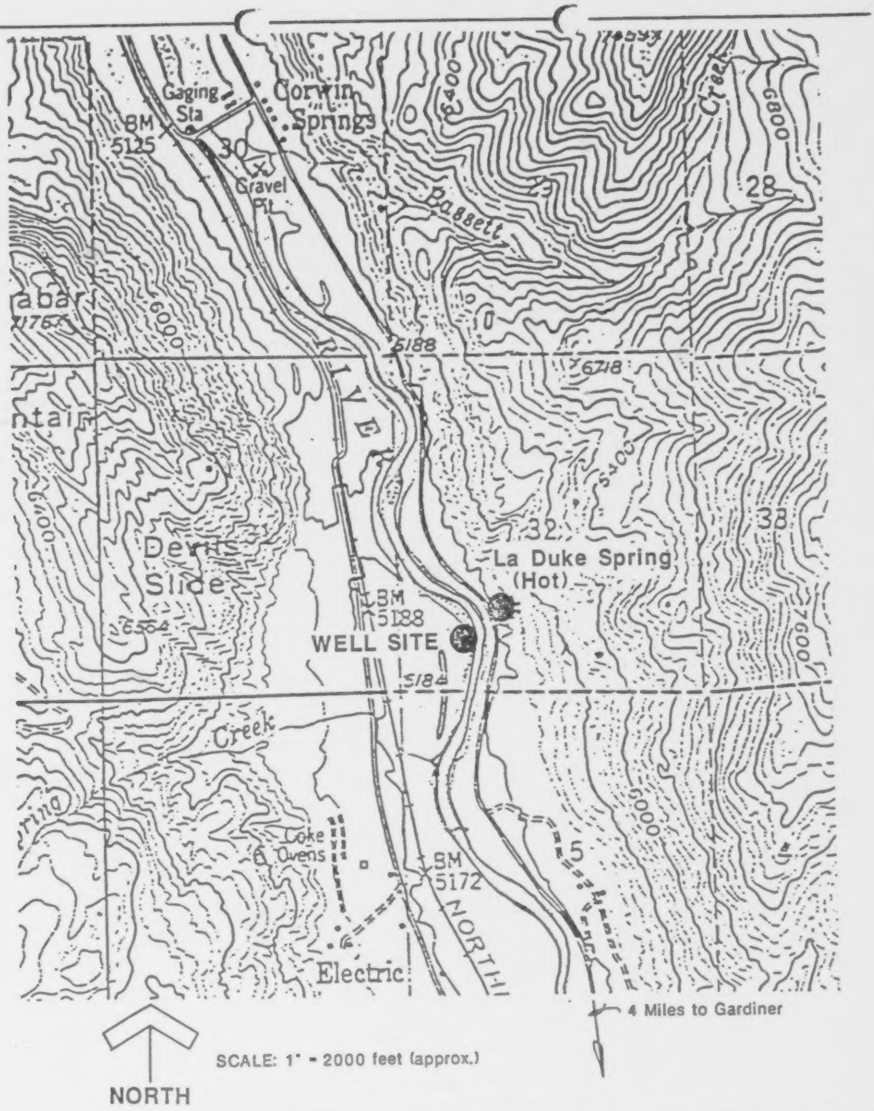

Gaging Sta
BM 5125
30
Corwin Springs
Gravel Pit
6400
Bassett
Creek
6800
28
6000
5188
6718
RIVER
6400
Devils Slide
32
La Duke Spring (Hot)
33
BM 5188
WELL SITE
6504
5184
7000
Creek
Coke Ovens
6
BM 5172
5
6000
Electric
NORTH
4 Miles to Gardiner
SCALE: 1" = 2000 feet (approx.)
NORTH

Figure 1: Location Map of La Duke Hot Spring Area

features in Yellowstone Park including Mammoth Hot Springs, located about 10 miles south of the thermal well site. To provide information on potential impacts of pumping the new thermal well on other thermal resources, Hydrometrics conducted a 13 hour pumping test of the thermal well. Well water levels, flow from the LaDuke Hot Spring and temperatures were monitored during the test to provide data on hydrogeology and hydraulics of the aquifer supplying LaDuke Hot Spring.

## AQUIFER TESTING

The thermal well was pumped at a constant rate of 400 gpm (gallons per minute) for 13.35 hours on September 15 and 16, 1986. Water levels in the well during pumping, and during recovery after pumping ceased, were measured with an electric probe. Aquifer test data were analyzed using standard straight line analytical techniques described by Cooper and Jacob (1946) and by Jacob (1963). A summary of aquifer test results is in Table 1 and graphical plots of aquifer test data are in Appendix 2. A water sample from the thermal well and LaDuke Hot Spring were collected and sent to Energy Laboratory in Billings, Montana for analysis. Results of the analysis are in Appendix 3.

Flow of water from LaDuke Hot Spring was measured periodically before pumping began, during pumping and after pumping stopped using a 3-inch throat Parshall flume. All flow measurements are summarized in Table 2.

TABLE 1. AQUIFER TEST SUMMARY

| Well Depth | SWL (ft) | Test Date | Test Type | Duration (min.) | Maximum Drawdown (ft) | Discharge Rate (gpm) | Specific Capacity (gpm/ft) | T* (gpd/ft) | Meassured T(°C) |
|---|---|---|---|---|---|---|---|---|---|
| 458 | 38.6 | 9/15,16/86 | Jacob Drawdown | 801 | 16.34 | 400 | 24.5 | 86,200 | 57 |
| | | 9/16/86 | Jacob Residual Drawdown | 429 | | | | 91,600 | |

NOTE: Water temperature was measured periodically throughout aquifer test. Temperature remained constant at 57°C.

* T is the calculated transmissivity of the aquifer tested.

## TABLE 2. FLOW AND TEMPERATURE MEASUREMENTS OF LADUKE HOT SPRING BEFORE, DURING, AND AFTER PUMPING OF THE THERMAL WELL

| Date | Time (Military) | Flow (gpm) | Temperature (°C) | Comments |
|---|---|---|---|---|
| 9/15/86 | 1330 | 52 | 58 | |
| | 1415 | 52 | 58 | |
| | 1525 | 52 | 57 | |
| | 1700 | 47 | 57 | Pump test started at 1539. |
| | 1835 | 29 | 57 | |
| | 2000 | 24 | 57 | |
| | 2145 | 19 | 57 | |
| 9/16/86 | 0145 | 13 | 57 | |
| | 0445 | 4 | 57 | |
| | 0615 | 11 | 57 | Pump test concluded at 0500. |
| | 0745 | 19 | 57 | |
| | 0845 | 23 | 57 | |
| | 1230 | 31 | 57 | |

NOTE: Flow measured with 3-inch Parshall flume.

Temperatures of LaDuke Hot Spring and the thermal well were measured periodically during and after the aquifer test. Temperatures of both the well and the hot spring were 57°C (135°F) throughout the test pumping period (see Tables 1 and 2, respectively).

## AQUIFER TESTING RESULTS

Average calculated transmissivity of the zone tapped by the thermal well, using both drawdown and residual drawdown data, is 89,000 gpd/ft. This is a moderately high transmissivity and indicates a good ability of the aquifer to transmit water to a well. The drillers log (Appendix 1) and water level information indicate the aquifer is confined with a potentiometric surface higher than the elevation of the Yellowstone River. The drillers logs shows "blue mud" down to 458 feet where "rock" was encountered. This probably is a shale overlying either limestone or volcanic rock. Figure 2 shows the relative elevations of the static water level in the thermal well, the LaDuke Hot Spring point of discharge and the Yellowstone River.

Quality of water in the thermal well and the LaDuke Hot Spring and temperature and spring flow data obtained during the aquifer test show the aquifer penetrated by the thermal well also is the source of water for LaDuke Hot Spring. Chemical quality and temperature of the thermal well water and water discharge from LaDuke Hot Spring are very similar (see Appendix 3). Table 2 shows flow from LaDuke Hot Spring declined continuously during the pumping test with a noticeable decrease in flow measured only 85 minutes after pumping began.

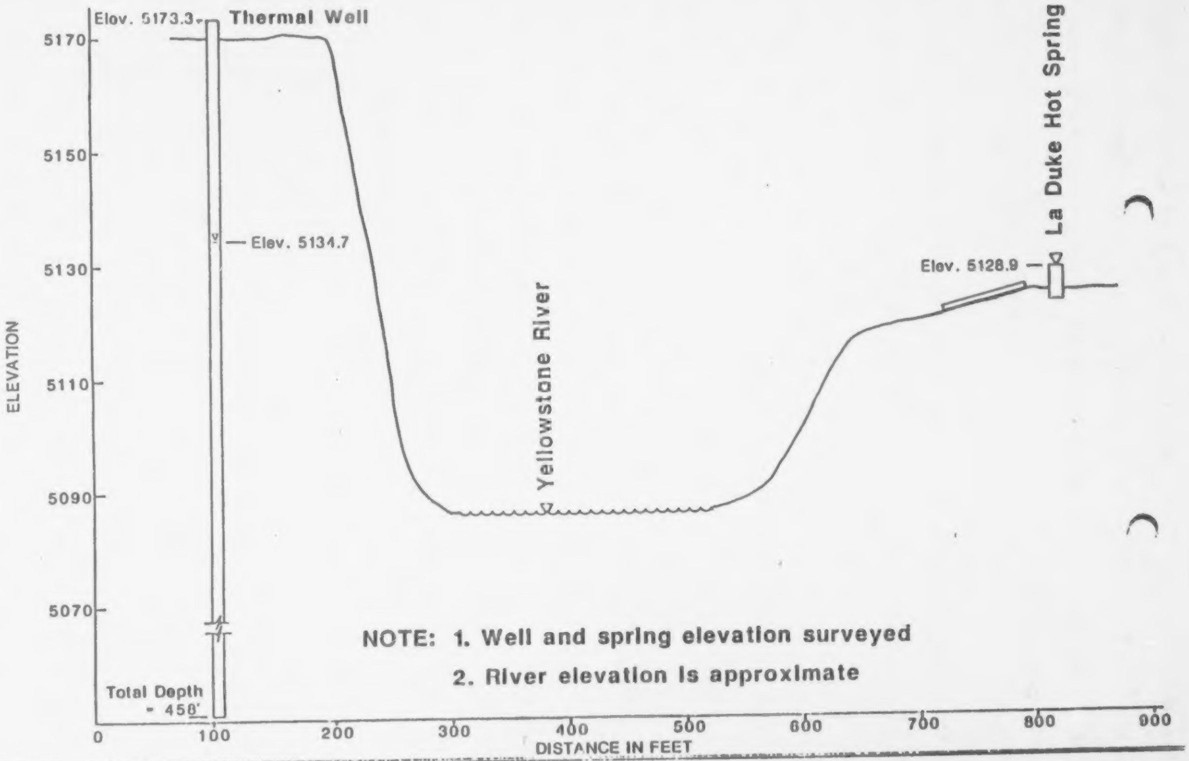


Figure 2: Relative Elevations of Water Levels of the Thermal Well, La Duke Hot Spring and the Yellowstone River

Measured flows at LaDuke Hot Spring declined from 52 gpm to as low as 4 gpm shortly before pumping ceased. Similarly, flow increases in LaDuke Hot Spring were measured shortly after pumping of the thermal well ceased (Table 2).

Photographs (Appendix 4) of flow from the spring house at the LaDuke Hot Spring show the reduction in flow during pumping of the thermal well.

## IMPACTS OF PUMPING THE THERMAL WELL

Royal Teton, Ltd. has eight claimed water rights for a total of 22.85 cfs (cubic feet per second) from LaDuke Hot Spring. The Montana Water Court has decreed all of these to Royal Teton, Ltd. in its Temporary Preliminary Decree on the Upper Yellowstone River (Basin 43B). Copies of these water rights are in Appendix 5. However, the Temporary Preliminary Decree has reduced one irrigation claim from 5 cfs to 3.79 cfs (No. 193864, see Appendix 5) and has not decreed flow rates for two recreation claims of 5 cfs each (Nos. 193870 and 193869, Appendix 5) leaving a remaining decreed flow of 11.6 cfs.

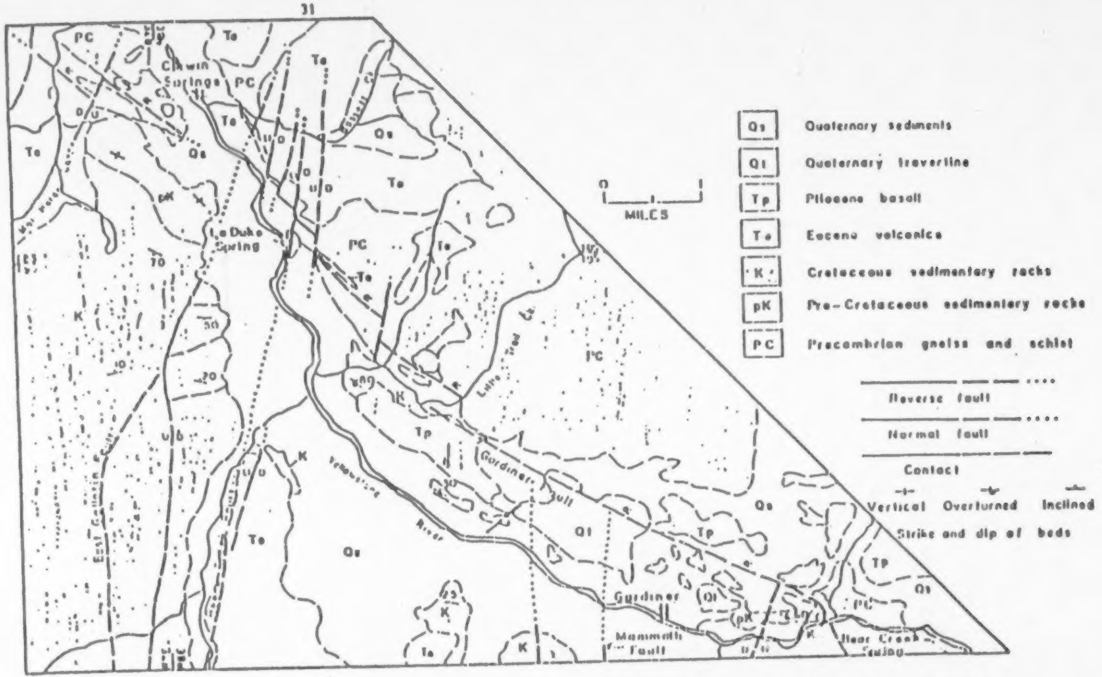
The new thermal well may be used to pump hot water at the rate of 400 to 500 gpm. Use of this thermal well would be considered by the Royal Teton, Ltd. to be a transfer of the point of diversion of their existing water rights on LaDuke Hot Spring. Based on U.S. Geological Survey records, LaDuke Hot Spring has a variable yield but in the past has had measured flow as high as 500 gpm (see Appendix 3).

Aquifer test results showed pumping of the Royal Teton Ranch thermal well at 400 gpm intercepted the majority of the visible flow from the LaDuke Hot Spring.* Potential impacts to more distant water resources including geothermal features in Yellowstone Park are essentially impossible to assess due to the very limited understanding of hydrological systems and geological characteristics in the area. There is little quantitative understanding of the interconnection of geothermal features in the general Yellowstone area. Some information on structural and lithologic controls in the Gardiner-Corwin Spring area has been obtained by the University of Montana. Water in the LaDuke Hot Spring is thought to derive its heat by descending to great depths along fracture zones or within permeable rock units. The thermal water at the LaDuke Hot Spring probably rises along the northwest-trending Gardiner Fault zone and emerges from fractures where the Reese Creek Fault intersects the Gardiner Fault (Figure 3). Recharge to the groundwater system may occur from two major sources:

1) Percolation of water in joints in the Precambrian gneiss along the Gardiner Fault (Figure 4);

2) Recharge to the Mission Canyon limestone which dips gently northward from the crest of the northwest-trending Gallatin anticline in Yellowstone Park to the Gardiner Fault (Figure 4).

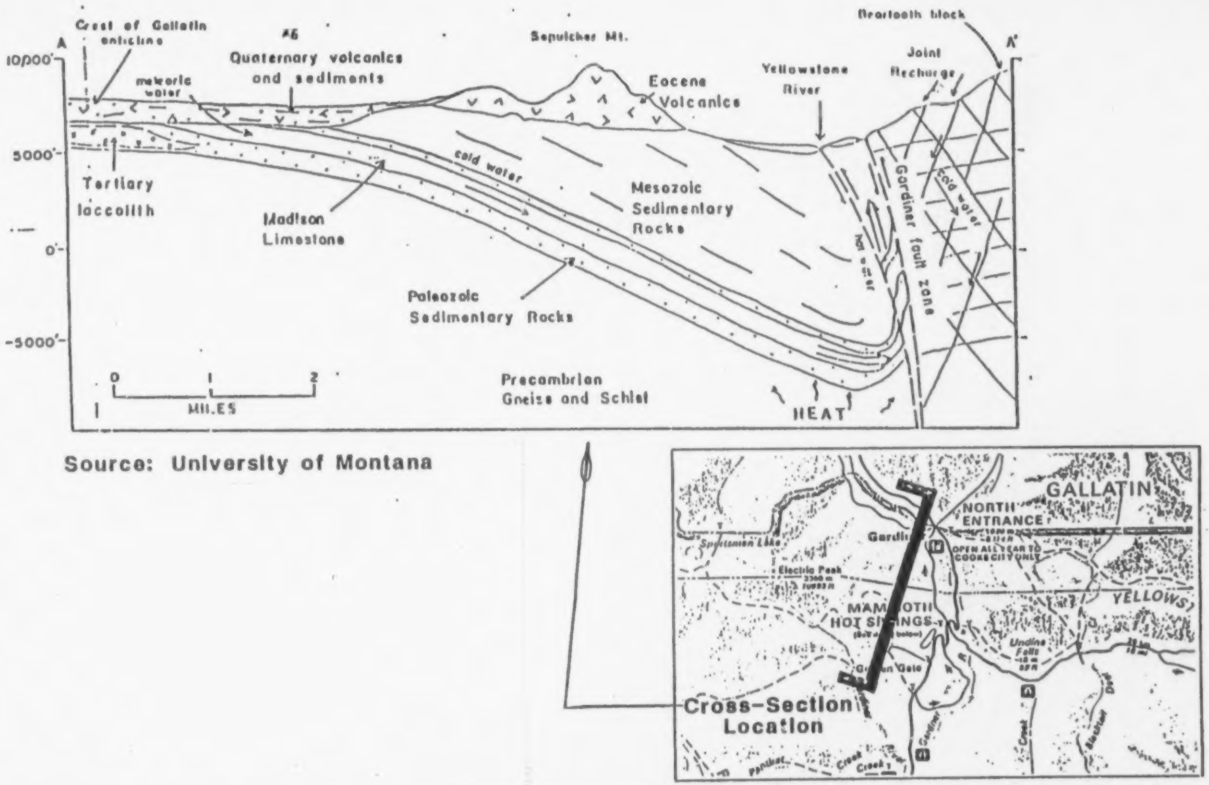
Cold recharge water is probably heated at depth and then rises through fractures at the Gardner Fault to the surface at LaDuke Hot Spring.



Qs Quaternary sediments
Qt Quaternary travertine
Tp Pliocene basalt
Te Eocene volcanics
K Cretaceous sedimentary rocks
pK Pre-Cretaceous sedimentary rocks
PC Precambrian gneiss and schist
Reverse fault
Normal fault
Contact
Vertical Overturned Inclined
Strike and dip of beds
0 1 MILES
Corwin Springs
LaDuke Spring
Gardiner fault
Gardiner
Mammoth Fault
Bear Creek fault
Yellowstone River
Eaton Gallatin
Te
PC
Qs
Qt
Tp
K
pK

(modified from Wilson, 1934, Fraser, 1969, Ruppel, 1972 and Struhsacker, 1976)

Figure 3 Bedrock Geology of the Corwin Springs - Gardiner Area


A
A'
10,000'
5000'
0'
-5000'
Crest of Gallatin anticline
meteoric water
#6
Quaternary volcanics and sediments
Tertiary laccolith
Madison Limestone
Sepulcher Mt.
Eocene Volcanics
cold water
Mesozoic Sedimentary Rocks
Paleozoic Sedimentary Rocks
Precambrian Gneiss and Schist
Yellowstone River
Beartooth block
Joint Recharge
Gardiner fault zone
hot water
cold water
HEAT
0
1
2
MILES
GALLATIN
NORTH ENTRANCE
Gardiner
OPEN ALL YEAR TO COOKE CITY ONLY
Sportsmen Lake
Electric Peak
MAMMOTH HOT SPRINGS
YELLOWSTONE
Undine Falls
Golden Gate
Cross-Section Location

Source: University of Montana

Figure 4 Geologic Cross-section Showing Possible Recharge Pattern For Corwin Springs - Gardiner Thermal Areas

*The aquifer encountered by the thermal well is confined and probably consists of fractured rock.

The hydrological effects of pumping 400 to 500 gpm from the Royal Teton Ranch thermal well are of considerable interest. Hydrological data show the well obtains water from the same aquifer that supplies LaDuke Hot Spring. Pumping of water from the thermal well probably will eliminate most of the visible flow from the LaDuke Hot Spring and would reduce subsurface flow of thermal groundwater into the Yellowstone River.

There are insufficient detailed hydrogeological data to quantitatively assess the impact of pumping of water from the thermal well on geothermal waters in Yellowstone National Park. Several technical considerations, however, indicate there should be no impact from pumping the Royal Teton Ranch thermal well on geothermal waters in Yellowstone National Park. These are:

1. The thermal well is approximately 10 miles distant and 500 feet lower in elevation than geothermal waters in Yellowstone National Park. This large distance and difference in elevation makes it quite unlikely that hydraulic impacts from pumping could be transmitted to Yellowstone Park.

2. Geological conditions including geological structure, stratigraphy and lithology of the many igneous and sedimentary formations in the general area makes it highly improbable that any hydraulic continuity exists between the LaDuke Hot Spring area and geothermal waters within Yellowstone National Park.

3. Discharge of thermal water from LaDuke Hot Spring is variable and has been measured within the last 14 years by the USGS as high as 500 gpm. It is quite likely there also is a significant subsurface discharge of thermal water from LaDuke Hot Spring area into the Yellowstone River. Pumping of water from the thermal well would intercept a portion of this naturally occurring discharge but may not significantly affect the overall rate of discharge of thermal water at LaDuke Hot Spring. Changing aquifer discharge from a natural discharge to discharge from a thermal well 700 feet distant should not affect regional geothermal water systems.

4. Yellowstone National Park thermal waters are far upgradient from LaDuke Hot Spring and if there is any connection between these waters there probably would be a movement of water from Yellowstone National Park downgradient toward the north. It is very unlikely that a discharge point such as the thermal well would have any impact on groundwater far upgradient of the thermal well.

For these reasons it seems highly unlikely that pumping of water from the Royal Teton Ranch at 400 to 500 gpm would have any impact on geothermal waters in Yellowstone National Park.

## REFERENCES

Cooper and Jacob, 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History: Am. Geophys. Union Trans., Volume 27, No. 4.

Jacob, C. E., 1963. Recovery Method for Determining the Coefficient of Transmissibility, Water Supply Paper 15361. U. S. Geological Survey, WA.

# APPENDIX 1

# DRILLING LOG OF THERMAL WELL

Form No. 603 (R 6-84)

File No. ______

# WELL LOG REPORT

*State law requires that this form be filed by the water well driller within 60 days after completion of the well.*

1. WELL OWNER
Name Royal Teton Ranch

2. CURRENT MAILING ADDRESS

3. WELL LOCATION
County PARK
Township 8 N [✓ S] Range 8 [✓ E] W
NE ¼ SW ¼ SW ¼ Section 32
Lot ______ Block ______
Subdivision ______

4. PROPOSED USE Domestic ☐ Stock ☐ Irrigation ☐
Other ☒ specify Municipal

5. DRILLING METHOD ______ cable, ______ bored,
x forward rotary, ______ reverse rotary, ______ jetted,
______ other (specify) ______

6. WELL CONSTRUCTION AND COMPLETION

| Size of drilled hole | Size and weight of casing | From (feet) | To (feet) | Perforations and/or Screen: Kind Size | From (feet) | To (feet) |
|---|---|---|---|---|---|---|
| 11 | 8⅝<br>28# | +1 | 420 | | | |

Was casing left open end? x Yes ______ No
Was a packer or seal used? ______ Yes x No
If so, what material ______
Was the well gravel packed? ______ Yes x No
Was the well grouted? x Yes ______ No
To what depth? 420
Material used in grouting Cement
Well head completion: Pitless adapter ______ Yes x No
Top of casing 12 in. or greater above grade ______ Yes ______ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
129 Degrees Fahrenheit
☒ Measured ☐ Estimated

8. WATER LEVEL
Static water level 40 feet below land surface
If flowing; closed-in pressure ______ psi
______ gpm
Controlled by: ______ valve, ______ reducers,
______ other, (specify) ______

9. WELL TEST DATA ______ pump ______ bailer
x other, (specify) air
Pumping water level below land surface:
______ ft. after ______ hrs. pumping ______ gpm
2 ft. after 410 hrs. pumping 600 gpm

10. WAS WELL PLUGGED OR ABANDONED? ______ Yes x No
If yes, how? ______

11. DATE COMPLETED 4-17-86

12. WELL LOG

| Depth (ft.) From | To | Formation |
|---|---|---|
| 0 | 1 | top soil |
| 1 | 30 | Gravel |
| 30 | 458 | Blue mud with [illegible] |
| 459 | | Rock |

(use separate sheet if necessary)

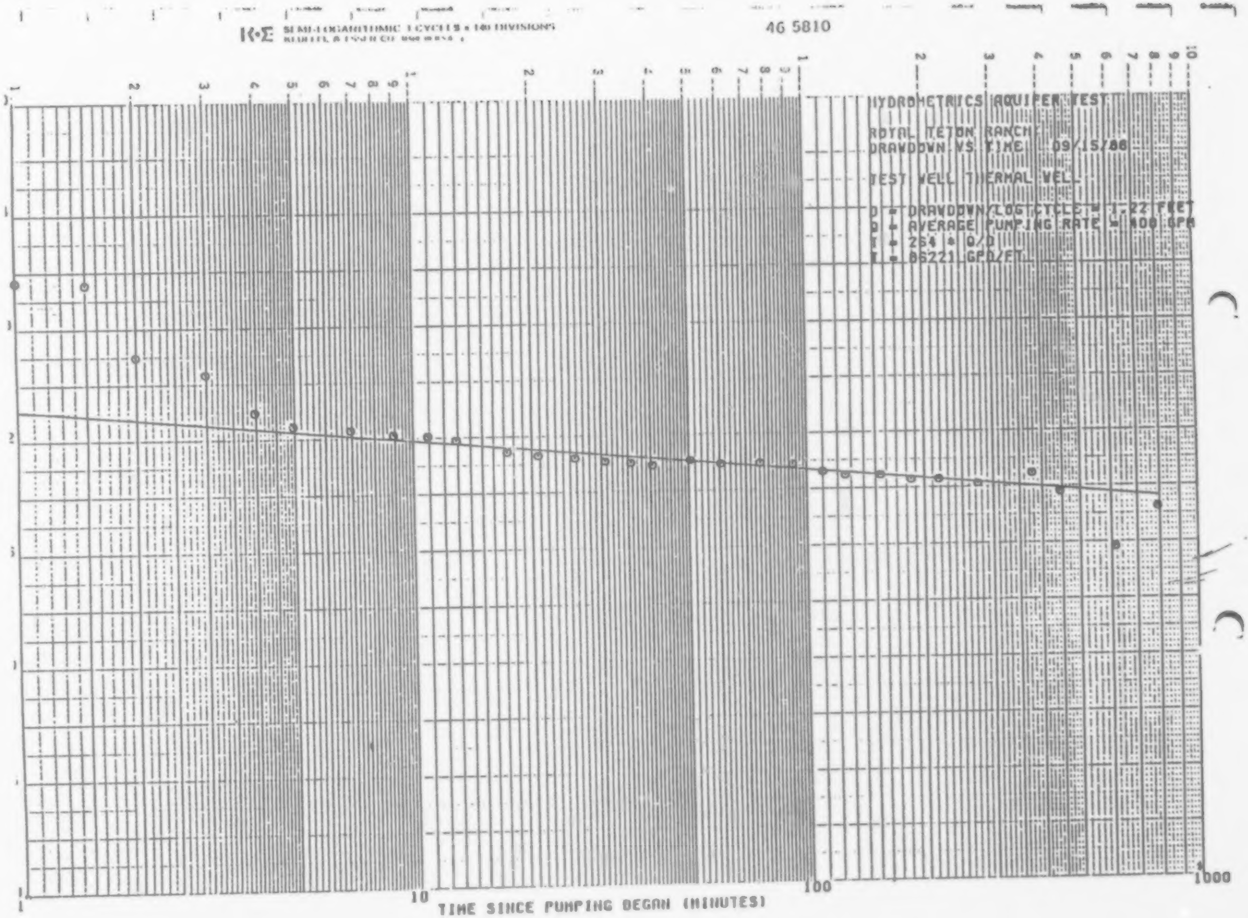
13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.
4-17-86
Date
Rock Creek Drilling
Firm Name
Rt 1 Box 155 Joliet MT
Address
Vern Kupfer
Signature
700
License No.

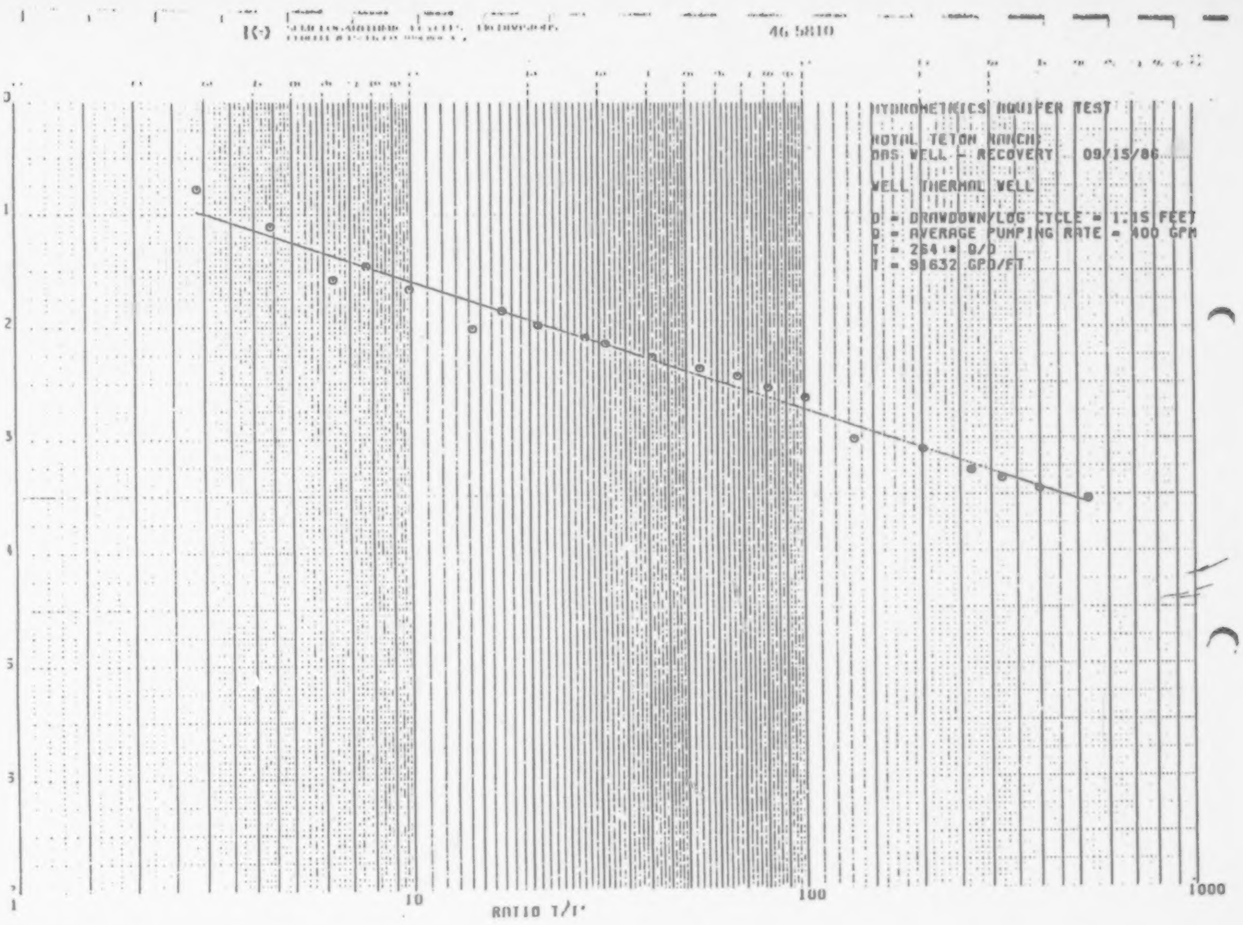
**MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION**
32 SOUTH EWING HELENA, MONTANA 59620
444-6610
DNRC

DEPARTMENT COPY

# APPENDIX 2

# AQUIFER TEST PLOTS

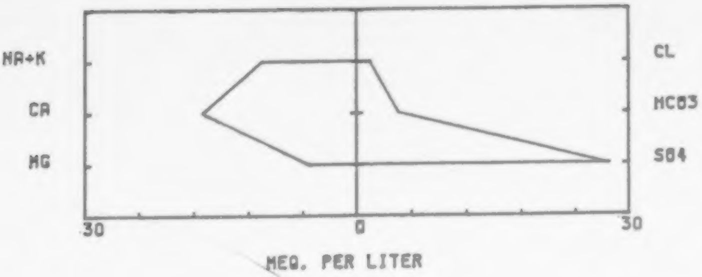

K•E SEMI-LOGARITHMIC 3 CYCLES × 140 DIVISIONS
46 5810
HYDROMETRICS AQUIFER TEST
ROYAL TETON RANCH
DRAWDOWN VS TIME 09/15/88
TEST WELL THERMAL WELL
D = DRAWDOWN/LOG CYCLE = 1.22 FEET
Q = AVERAGE PUMPING RATE = 400 GPM
T = 264 * Q/D
T = 86221 GPD/FT
1
10
100
1000
TIME SINCE PUMPING BEGAN (MINUTES)


HYDROMETRICS AQUIFER TEST
ROYAL TETON RANCH
OBS WELL - RECOVERY 09/15/86
WELL THERMAL WELL
D = DRAWDOWN/LOG CYCLE = 1.15 FEET
Q = AVERAGE PUMPING RATE = 400 GPM
T = 264 * Q/D
T = 91632 GPD/FT
0
1
2
3
4
5
6
7
1
10
100
1000
RATIO T/T'
46 5810

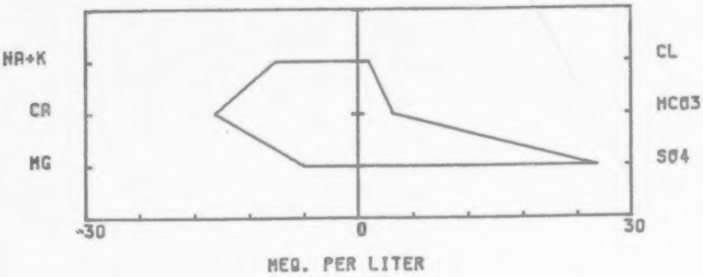
# APPENDIX 3

# WATER QUALITY ANALYTICAL RESULTS

# STIFF DIAGRAMS



LADUKE HOT SPRINGS
12/15/86



THERMAL TEST WELL
09/16/86

ENERGY LABORATORIES

ENERGY LABORATORIES, INC.
P.O. BOX 30916 · 1107 SOUTH BROADWAY · BILLINGS, MT 59107-0916 · PHONE (406) 252-6325

RECEIVED
OCT 7 1986

LABORATORY REPORT

PAGE : 1

To : Hydrometrics
Address : 2727 Airport Road
Helena, MT 59601

Lab No. : 86-8854
Date : 10/ 6/86

WATER ANALYSIS REPORT

Sample Pt Name : Thermal Test Well
Sample Date : 9/16/86
Sample Time : 05:00:00
Sample Received : 9/17/86
Royal Teton Ranch

LABORATORY DATA:

| | | |
|---|---|---|
| Potassium, Dissolved | (mg/l) | 26 |
| Sodium, Dissolved | (mg/l) | 208 |
| Calcium, Dissolved | (mg/l) | 316 |
| Magnesium, Dissolved | (mg/l) | 72 |
| Sulfate as SO4 | (mg/l) | 1260 |
| Chloride | (mg/l) | 40 |
| Carbonate as CO3 | (mg/l) | 0 |
| Bicarbonate as HCO3 | (mg/l) | 229 |
| Solids, Dissolved @ 180 degrees C | (mg/l) | 2090 |
| Total Hardness as CaCO3 | (mg/l) | 1080 |
| Alkalinity, Total as CaCO3, pH 3.7 | (mg/l) | 187 |
| Specific Conductance @ 25 degrees C | (umhos/cm) | 2410 |
| pH @ 25 degrees C, s.u. | (s.u.) | 7.0 |
| Nitrate + Nitrite as N | (mg/l) | <0.05 |
| Ortho-phosphate as P | (mg/l) | <0.01 |
| Phosphorus, Total | (mg/l) | 0.02 |
| Nitrogen, Ammonia | (mg/l) | 0.4 |
| Nitrogen, Total Kjeldahl | (mg/l) | 0.8 |
| Fluoride | (mg/l) | 2.8 |
| Aluminum, Dissolved | (mg/l) | <0.1 |
| Arsenic, Dissolved | (mg/l) | 0.025 |
| Barium, Dissolved | (mg/l) | <0.1 |
| Cadmium, Dissolved | (mg/l) | <0.001 |
| Chromium, Dissolved | (mg/l) | <0.02 |
| Copper, Dissolved | (mg/l) | <0.01 |
| Iron, Dissolved | (mg/l) | 0.17 |
| Lead, Dissolved | (mg/l) | <0.01 |
| Manganese, Dissolved | (mg/l) | 0.10 |
| Mercury, Dissolved | (mg/l) | <0.001 |
| Molybdenum, Dissolved | (mg/l) | 0.007 |
| Selenium, Dissolved | (mg/l) | <0.005 |
| Silver, Dissolved | (mg/l) | <0.005 |
| Zinc, Dissolved | (mg/l) | 0.01 |

cc:

ENERGY LABORATORIES
ENERGY LABORATORIES, INC.
P.O. BOX [illegible] LABORATORY REPORT [illegible]INGS, MT 59107-0916 [illegible] (406) 252-6325

DEC 23 1986

To : Hydrometrics
Address : 2727 Airport Road
Helena, MT 59601

Lab No. : 86-12410
Date : 12/22/86

## WATER ANALYSIS REPORT

Sample Pt Name : LaDuke Hot Springs
Sample Date : 12/15/86
Sample Time : 15:15:00
Sample Received : 12/17/86

ABORATORY DATA:

| | | |
|---|---|---|
| Potassium, Dissolved | (mg/l) | 23 |
| Sodium, Dissolved | (mg/l) | 240 |
| alcium, Dissolved | (mg/l) | 342 |
| agnesium, Dissolved | (mg/l) | 63 |
| Sulfate as SO4 | (mg/l) | 1340 |
| Chloride | (mg/l) | 51 |
| arbonate as CO3 | (mg/l) | 0 |
| Bicarbonate as HCO3 | (mg/l) | 278 |
| Solids, Dissolved @ 180 degrees C | (mg/l) | 2220 |
| otal Hardness as CaCO3 | (mg/l) | 1110 |
| Alkalinity, Total as CaCO3, pH 4.5 | (mg/l) | 228 |
| Cond., umhos/cm @ 25 degrees C | (umhos/cm) | 2540 |
| H @ 25 degrees C, s.u. | (s.u.) | 6.7 |
| itrate + Nitrite as N | (mg/l) | 0.07 |
| Nitrogen, Ammonia | (mg/l) | 0.2 |
| Fluoride | (mg/l) | 3.8 |
| luminum, Dissolved | (mg/l) | <0.1 |
| Arsenic, Dissolved | (mg/l) | 0.020 |
| Barium, Dissolved | (mg/l) | <0.1 |
| admium, Dissolved | (mg/l) | 0.007 |
| Chromium, Dissolved | (mg/l) | <0.02 |
| Copper, Dissolved | (mg/l) | <0.01 |
| ron, Dissolved | (mg/l) | 0.14 |
| Lead, Dissolved | (mg/l) | <0.01 |
| Manganese, Dissolved | (mg/l) | <0.02 |
| ercury, Dissolved | (mg/l) | <0.001 |
| olybdenum, Dissolved | (mg/l) | <0.005 |
| Selenium, Dissolved | (mg/l) | 0.008 |
| Silver, Total | (mg/l) | <0.005 |
| inc, Dissolved | (mg/l) | 0.02 |

c:

# Historical Data LaDuke Hot Springs

## CHEMICAL ANALYSES OF WATER FROM THE LA DUKE (CORWIN) HOT SPRINGS AREA

| STATION NUMBER | STATION LETTER AND NAME | | DATE OF SAMPLE | SAM-PLED BY | FLOW RATE (GPM) | SPE-CIFIC CON-DUCT-ANCE (MICRO-MHOS) | PH (UNITS) |
|---|---|---|---|---|---|---|---|
| 450535110462500 | A | LA DUKE (CORWIN) HOT SPRINGS 6N9W08L3/CD | 72-07-26 | MBMG | 500 | 2800 | 7.0 |
| | A | LA DUKE (CORWIN) HOT SPRINGS 6N9W08L3/CD | 75-07-02 | USGS | 132 | 2800 | 6.5 |
| | A | LA DUKE (CORWIN) HOT SPRINGS 6N9W08L3/CD | 76-05-27 | USGS | 220 | 2600 | -- |

| STA-TION LETTER | DATE OF SAMPLE | TEMPER-ATURE (DEG C) | HYDRO-GEN SULFIDE (MG/L) | HARD-NESS (CA,MG) (MG/L) | NON-CAR-BONATE HARD-NESS (MG/L) | DIS-SOLVED CAL-CIUM (CA) (MG/L) | DIS-SOLVED MAG-NE-SIUM (MG) (MG/L) | DIS-SOLVED SODIUM (NA) (MG/L) | PERCENT SODIUM | SODIUM AD-SORP-TION RATIO | DIS-SOLVED PO-TAS-SIUM (K) (MG/L) | BICAR-BONATE (HCO3) (MG/L) | CAR-BONATE (CO3) (MG/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 72-07-26 | 66.5 | -- | 940 | 867 | 270 | 80 | 239 | 33 | 3.1 | 20 | 96 | 0 |
| A | 75-07-02 | 65.0 | <1.0 | 1000 | 796 | 320 | 58 | 230 | 31 | 3.1 | 23 | 303 | <1 |
| A | 76-05-27 | 67.5 | -- | 1100 | 850 | 330 | 81 | 240 | 32 | 3.2 | 25 | 201 | -- |

| STA-TION LETTER | DATE OF SAMPLE | HY-DROX-IDE (OH) (MG/L) | ALKA-LINITY AS CACO3 (MG/L) | CARBON DIOXIDE (CO2) (MG/L) | DIS-SOLVED SULFATE (SO4) (MG/L) | DIS-SOLVED CHLO-RIDE (CL) (MG/L) | DIS-SOLVED FLUO-RIDE (F) (MG/L) | DIS-SOLVED SILICA (SIO2) (MG/L) | DIS-SOLVED SOLIDS (SUM OF CONSTI-TUENTS) (MG/L) | DIS-SOLVED SOLIDS (TONS PER AC-FT) | DIS-SOLVED NITRATE (N) (MG/L) | DIS-SOLVED NITRATE (NO3) (MG/L) | DIS-SOLVED NITRITE PLUS NITRATE (N) (MG/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 72-07-26 | 0 | 77 | 3.8 | 1300 | 82 | 3.6 | 52 | 2070 | -- | .00 | .00 | -- |
| A | 75-07-02 | -- | 246 | 152 | 1200 | 85 | 3.0 | 49 | 2080 | -- | -- | -- | -- |
| A | 76-05-27 | -- | 230 | -- | 1400 | 82 | 3.5 | 65 | 2290 | 3.11 | -- | -- | .03 |

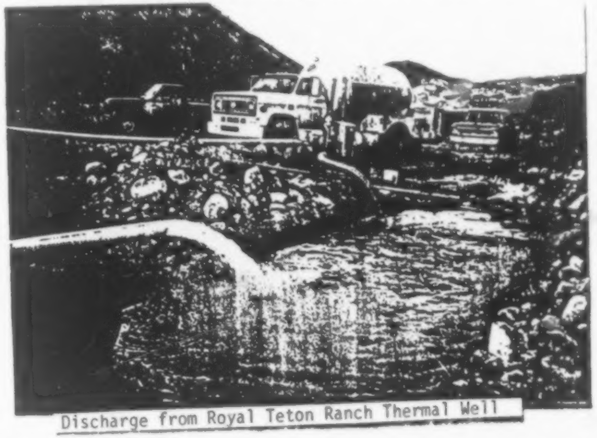
| STA-TION LETTER | DATE OF SAMPLE | DIS-SOLVED AMMONIA NITRO-GEN (N) (MG/L) | DIS-SOL-VED-PHOS-PHORUS (P) (MG/L) |
|---|---|---|---|
| A | 72-07-26 | -- | -- |
| A | 75-07-02 | .22 | -- |
| A | 76-05-27 | -- | .00 |

| STA-TION LETTER | DATE OF SAMPLE | DIS-SOLVED ALUM-INUM (AL) (UG/L) | DIS-SOLVED BORON (B) (UG/L) | DIS-SOLVED LITHIUM (LI) (UG/L) | TOTAL IRON (FE) (UG/L) | DIS-SOLVED IRON (FE) (UG/L) | DIS-SOLVED MAN-GANESE (MN) (UG/L) | DIS-SOLVED STRON-TIUM (SR) (UG/L) | DIS-SOLVED CESIUM (CS) (UG/L) | DIS-SOLVED RUBI-DIUM (RB) (UG/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 72-07-26 | -- | -- | 200 | 263 | -- | 20 | -- | -- | -- |
| A | 75-07-02 | <1 | 460 | 240 | -- | 160 | 20 | -- | <100 | 70 |
| A | 76-05-27 | -- | 480 | 270 | -- | 300 | -- | 3900 | -- | -- |

Source: U. S. Geological Survey
Water Resources Data for Montana

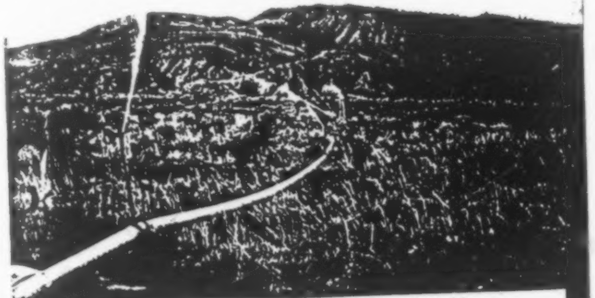
# APPENDIX 4

# PHOTOGRAPHS



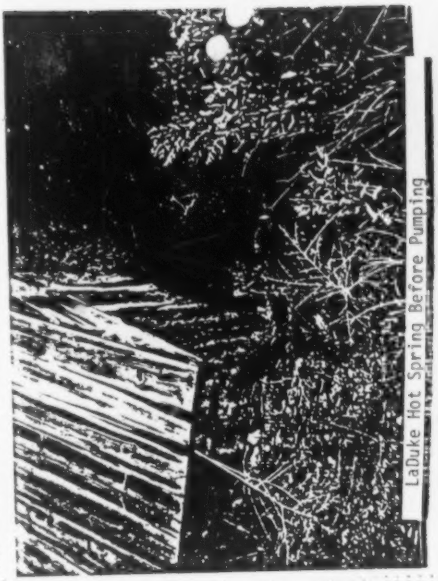
Discharge from Royal Teton Ranch Thermal Well

Vertical Turbine Pump - Thermal Well at
Royal Teton Ranch



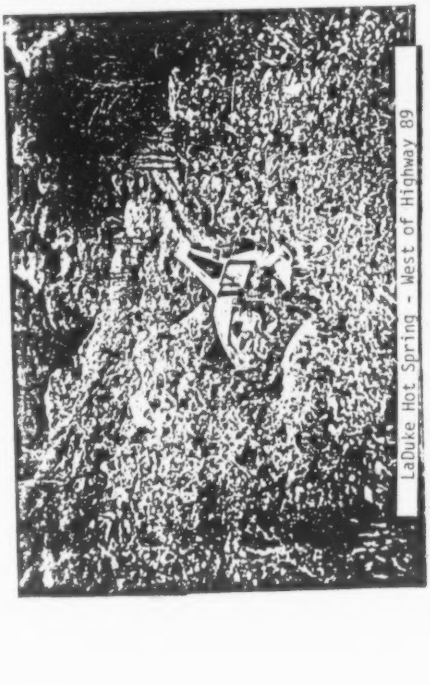
Disposal of Water from Thermal Well at
Royal Teton Ranch

Discharge from Royal Teton Ranch Thermal Well

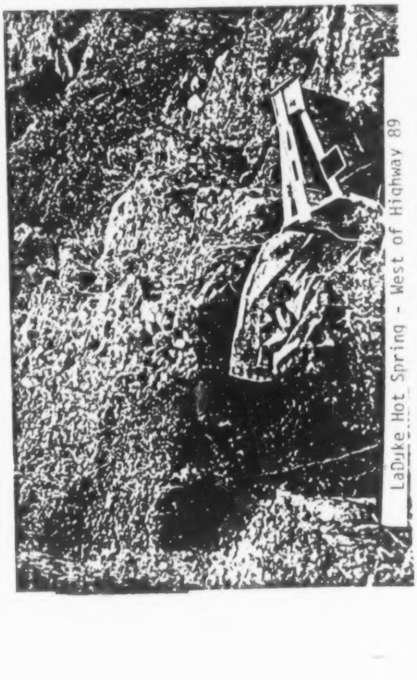


LaDuke Hot Spring Before Pumping

LaDuke Hot Spring After Pumping 13 Hours



LaDuke Hot Spring - West of Highway 89



LaDuke Hot Spring - West of Highway 89

# APPENDIX 5

# ABSTRACTS OF WATER RIGHTS TO THE LADUKE HOT SPRING

TEMPORARY P[illegible]LIMINARY DECREE ON YELLOWS[illegible]NE RIVER
ABOVE AND INCLUDING BRIDGER CREEK
ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-194912-00

OWNERS: CONNOR TIMOTHY J
RIVER RT BOX 460
GARDINER MT 59030

PRIORITY DATE: SEPT 18, 1899

FLOW RATE: 2.50 CFS

VOLUME: 907.22 ACRE FEET PER YEAR

SOURCE: LADUKE SPRINGS

PURPOSE (USE): COMMERCIAL

PERIOD OF USE: JAN 1 TO DEC 31

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 09S | 08E | PARK | HEADGATE |

PLACE OF USE FOR COMMERCIAL

| ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|
| 001 | | | SENENW | 30 | 08S | 08E | PARK |

REMARKS: THE WATER RIGHTS LISTED FOLLOWING THIS STATEMENT ARE MULTIPLE USES OF THE SAME RIGHT. THE USE OF THE RIGHT FOR SEVERAL PURPOSES DOES NOT INCREASE THE EXTENT OF THE WATER RIGHT. RATHER IT DECREES THE RIGHT TO INTERCHANGE THE USE (PURPOSE) OF THE WATER IN ACCORD WITH HISTORIC PRACTICES.
W196266-00, W194912-00

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

# TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
# ABOVE AND INCLUDING BRIDGER CREEK
## ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-196266-00

OWNERS: CONNOR TIMOTHY J
RIVER RT BOX 480
GARDINER MT 59030

PRIORITY DATE: SEPT 18, 1899

FLOW RATE: 0.28 CFS

VOLUME: 54.00 ACRE FEET PER YEAR

STANDARDS ON VOLUMES FOUND IN THE FINDINGS OF FACT ARE ONLY GUIDELINES. THE VOLUME CALCULATED USING THESE STANDARDS MAY BE MODIFIED BY THE COURT ON INDIVIDUAL OBJECTION.

CLIMATIC AREA: 5

SOURCE: LADUKE SPRINGS

MAXIMUM ACRES: 7.50

PURPOSE (USE): IRRIGATION

PERIOD OF USE: APR 15 TO NOV 19

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 09S | 08E | PARK | HEADGATE |

PLACE OF USE FOR IRRIGATION

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | 7.50 | | | SENENW | 30 | 08S | 08E | PARK |
| TOTAL | 7.50 | | | | | | | |

REMARKS: THE WATER RIGHTS LISTED FOLLOWING THIS STATEMENT ARE MULTIPLE USES OF THE SAME RIGHT. THE USE OF THE RIGHT FOR SEVERAL PURPOSES DOES NOT INCREASE THE EXTENT OF THE WATER RIGHT. RATHER IT DECREES THE RIGHT TO INTERCHANGE THE USE (PURPOSE) OF THE WATER IN ACCORD WITH HISTORIC PRACTICES.
W196266-00, W194912-00.

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
ABOVE AND INCLUDING BRIDGER CREEK
ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-194913-00

OWNERS: CONNOR TIMOTHY J
RIVER RT BOX 480
GARDINER MT 59030

PRIORITY DATE: SEPT 18, 1899

FLOW RATE: 0.07 CFS

VOLUME: 50.00 ACRE FEET PER YEAR

SOURCE: LADUKE SPRINGS

PURPOSE (USE): DOMESTIC

PERIOD OF USE: JAN 1 TO DEC 31

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 09S | 08E | PARK | DITCH |

PLACE OF USE FOR DOMESTIC

| ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|
| 001 | | | SENENW | 30 | 08S | 08E | PARK |

REMARKS: THIS CLAIM PRESENTS ISSUES OF LAW AND FACT THAT MAY BE ADDRESSED AT THE OBJECTION STAGE. IT APPEARS THAT THE CLAIMED FLOW RATE, VOLUME AND PRIORITY DATE ARE IN QUESTION.

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

# TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
# ABOVE AND INCLUDING BRIDGER CREEK
# ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-193584-00

OWNERS: BROGAN WELCH E
BOX 888
CORWIN SPRINGS MT 59021

PRIORITY DATE: OCT 3, 1907

FLOW RATE: 2.50 CFS

VOLUME: 907.22 ACRE FEET PER YEAR

SOURCE: LADUKE SPRINGS

PURPOSE (USE): COMMERCIAL

MEDICINAL BATHING

PERIOD OF USE: JAN 1 TO DEC 31

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 08S | 08E | PARK | HEADGATE |

PLACE OF USE FOR COMMERCIAL

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | | | | NESW | 19 | 08S | 08E | PARK |
| 002 | | | | SENW | 19 | 08S | 08E | PARK |
| 003 | | | | | 19 | 08S | 08E | PARK |
| 004 | | | | | 30 | 08S | 08E | PARK |

REMARKS: SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

## TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
## ABOVE AND INCLUDING BRIDGER CREEK
## ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-193864-00

OWNERS: BROGAN WELCH E
BOX 888
CORWIN SPRINGS MT 59021

PRIORITY DATE: OCT 23, 1958

FLOW RATE: 3.79 CFS

VOLUME: 100.00 ACRE FEET PER YEAR

STANDARDS ON VOLUMES FOUND IN THE FINDINGS OF FACT ARE ONLY GUIDELINES. THE VOLUME CALCULATED USING THESE STANDARDS MAY BE MODIFIED BY THE COURT ON INDIVIDUAL OBJECTION.

CLIMATIC AREA: 5

SOURCE: LADUKE SPRINGS

MAXIMUM ACRES: 100.00

PURPOSE (USE): IRRIGATION

PERIOD OF USE: MAY 1 TO OCT 4

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 08S | 08E | PARK | HEADGATE |

PLACE OF USE FOR IRRIGATION

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | 16.00 | | | NESW | 19 | 08S | 08E | PARK |
| 002 | 35.00 | | | SENW | 19 | 08S | 08E | PARK |
| 003 | 8.50 | (GOVT) 6 | | | 19 | 08S | 08E | PARK |
| 004 | 40.50 | | | | 30 | 08S | 08E | PARK |
| TOTAL | 100.00 | | | | | | | |

REMARKS: THE WATER RIGHTS LISTED FOLLOWING THIS STATEMENT ARE MULTIPLE USES OF THE SAME RIGHT. THE USE OF THE RIGHT FOR SEVERAL PURPOSES DOES NOT INCREASE THE EXTENT OF THE WATER RIGHT. RATHER IT DECREES THE RIGHT TO INTERCHANGE THE USE (PURPOSE) OF THE WATER IN ACCORD WITH HISTORIC PRACTICES.
W193869-00,W193864-00.

THE WATER RIGHTS FOLLOWING THIS STATEMENT ARE SUPPLEMENTAL, WHICH MEANS THE RIGHTS HAVE OVERLAPPING PLACES OF USE. THE RIGHTS CAN BE COMBINED TO IRRIGATE ONLY OVERLAPPING PARCELS OF THE CLAIMANT'S TOTAL 100.00 ACRES. THE COMBINED VOLUME OF THESE RIGHTS SHALL NOT EXCEED 720.00 ACRE-FEET PER YEAR. EACH RIGHT IS LIMITED TO THE FLOW RATE, VOLUME, PLACE OF USE AND BENEFICIAL USE OF THAT INDIVIDUAL RIGHT.
W193860-00, W193861-00, W193862-00, W193863-00, W193864-00,
W193865-00, W193866-00, W193867-00, W193868-00

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
ABOVE AND INCLUDING BRIDGER CREEK
ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-193869-00

OWNERS: BROGAN WELCH E
BOX 888
CORWIN SPRINGS MT 59021

PRIORITY DATE: OCT 23. 1958

FLOW RATE:

VOLUME:

THIS USE MAY CONSUME SOME WATER BUT UNTIL THAT AMOUNT IS QUANTIFIED. IT IS PRESUMED THAT THE USE IS NON-CONSUMPTIVE.

SOURCE: LADUKE SPRINGS

PURPOSE (USE): RECREATION

PERIOD OF USE: JAN 1 TO DEC 31

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 08S | 08E | PARK | PIPELINE |

PLACE OF USE FOR RECREATION

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | | | | | 19 | 08S | 08E | PARK |
| 002 | | | | | 30 | 08S | 08E | PARK |

REMARKS: DIVERSION MEANS:
CONCRETE COLLECTOR RESERVOIR.

THIS RIGHT IS RECOGNIZED AS A BENEFICIAL USE OF WATER. FLOW RATE AND VOLUME. THOUGH NOT SPECIFICALLY DECREED. ARE LIMITED TO THE MINIMUM AMOUNTS NECESSARY TO SUSTAIN THIS PURPOSE. THIS RIGHT SHALL CONTINUE TO BE UTILIZED IN ACCORDANCE WITH PAST PRACTICES.

THE WATER RIGHTS LISTED FOLLOWING THIS STATEMENT ARE MULTIPLE USES OF THE SAME RIGHT. THE USE OF THE RIGHT FOR SEVERAL PURPOSES DOES NOT INCREASE THE EXTENT OF THE WATER RIGHT. RATHER IT DECREES THE RIGHT TO INTERCHANGE THE USE (PURPOSE) OF THE WATER IN ACCORD WITH HISTORIC PRACTICES.
W193869-00.W193864-00.

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

## TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
## ABOVE AND INCLUDING BRIDGER CREEK
## ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-193868-00

OWNERS: BROGAN WELCH E
BOX 888
CORWIN SPRINGS MT 59021

PRIORITY DATE: OCT 3. 1907

FLOW RATE: 2.50 CFS

VOLUME: 500.00 ACRE FEET PER YEAR

STANDARDS ON VOLUMES FOUND IN THE FINDINGS OF FACT ARE ONLY GUIDELINES. THE VOLUME CALCULATED USING THESE STANDARDS MAY BE MODIFIED BY THE COURT ON INDIVIDUAL OBJECTION.

CLIMATIC AREA: 5

SOURCE: LADUKE SPRINGS

MAXIMUM ACRES: 100.00

PURPOSE (USE): IRRIGATION

PERIOD OF USE: MAY 1 TO OCT 4

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 08S | 08E | PARK | HEADGATE |

PLACE OF USE FOR IRRIGATION

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | 16.00 | | | NESW | 19 | 08S | 08E | PARK |
| 002 | 35.00 | | | SENW | 19 | 08S | 08E | PARK |
| 003 | 8.50 | (GOVT) 6 | | | 19 | 08S | 08E | PARK |
| 004 | 40.50 | | | | 30 | 08S | 08E | PARK |
| TOTAL | 100.00 | | | | | | | |

REMARKS: THE WATER RIGHTS FOLLOWING THIS STATEMENT ARE SUPPLEMENTAL. WHICH MEANS THE RIGHTS HAVE OVERLAPPING PLACES OF USE. THE RIGHTS CAN BE COMBINED TO IRRIGATE ONLY OVERLAPPING PARCELS OF THE CLAIMANT'S TOTAL 100.00 ACRES. THE COMBINED VOLUME OF THESE RIGHTS SHALL NOT EXCEED 720.00 ACRE-FEET PER YEAR. EACH RIGHT IS LIMITED TO THE FLOW RATE. VOLUME. PLACE OF USE AND BENEFICIAL USE OF THAT INDIVIDUAL RIGHT.
W193860-00. W193861-00. W193862-00. W193863-00. W193864-00.
W193865-00. W193866-00. W193867-00. W193868-00

THIS CLAIM PRESENTS ISSUES OF LAW AND FACT THAT MAY BE ADDRESSED AT THE OBJECTION STAGE. IT APPEARS THAT 79.5 ACRES ARE ACTUALLY IRRIGATED AT THIS TIME.

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

TEMPORARY PRELIMINARY DECREE ON YELLOWSTONE RIVER
ABOVE AND INCLUDING BRIDGER CREEK
ABSTRACT OF WATER RIGHT

WATER RIGHT NUMBER 43B -W-193870-00

OWNERS: BROGAN WELCH E
BOX 888
CORWIN SPRINGS MT 59021

PRIORITY DATE: MAR 13, 1954

FLOW RATE:

VOLUME:

THIS USE MAY CONSUME SOME WATER BUT UNTIL THAT AMOUNT IS QUANTIFIED, IT IS PRESUMED THAT THE USE IS NON-CONSUMPTIVE.

SOURCE: LADUKE SPRINGS

PURPOSE (USE): RECREATION

PERIOD OF USE: JAN 1 TO DEC 31

POINTS OF DIVERSION AND MEANS OF DIVERSION:

| LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY | |
|---|---|---|---|---|---|---|---|
| | | NWSESW | 32 | 08S | 08E | PARK | HEADGATE |

PLACE OF USE FOR RECREATION

| | ACRES | LOT | BLK | QTR SEC | SEC | TWP | RGE | COUNTY |
|---|---|---|---|---|---|---|---|---|
| 001 | | | | | 19 | 08S | 08E | PARK |
| 002 | | | | | 30 | 08S | 08E | PARK |

REMARKS: THIS RIGHT IS RECOGNIZED AS A BENEFICIAL USE OF WATER. FLOW RATE AND VOLUME, THOUGH NOT SPECIFICALLY DECREED, ARE LIMITED TO THE MINIMUM AMOUNTS NECESSARY TO SUSTAIN THIS PURPOSE. THIS RIGHT SHALL CONTINUE TO BE UTILIZED IN ACCORDANCE WITH PAST PRACTICES.

SEE GENERAL FINDINGS OF FACT AND CONCLUSIONS OF LAW FOR FURTHER DELINEATION OF THIS RIGHT.

# DRAFT

# WATER PRODUCTION TESTS OF
LADUKE HOT SPRING
PARK COUNTY, MONTANA

for

Royal Teton Ranch
Box A
Corwin Springs, MT 59021

by

HYDROMETRICS
2727 Airport Road
Helena, MT 59601
406/443-4150

June 1987

# WATER PRODUCTION TESTS OF LADUKE HOT SPRING PARK COUNTY, MONTANA

## 1.0 INTRODUCTION

At the request of Mr. Edward Francis of the Royal Teton Ranch, Hydrometrics conducted tests of water production from the LaDuke Hot Spring. Additionally, the bank of the Yellowstone River near LaDuke Hot Spring was examined for the presence of thermal water flows. This report describes results of this testing.

## 2.0 LOCATION AND CHARACTERISTICS

The LaDuke Hot Spring area lies in SW¼, Section 32, Township 8 South, Range 8 East, MPM, Park County, Montana. Figure 1 is a sketch map of the spring area. The spring is actually a geothermal discharge area with thermal water outlets concentrated in a zone at least 1000-feet long and 100-feet wide. The observed thermal springs and seeps discharge directly into the adjacent Yellowstone River. A previous evaluation by Hydrometrics (1986) of a proposed geothermal well on the Royal Teton Ranch included a general geological and topographic description of the LaDuke Hot Spring area.

### Spring Box

The main spring at LaDuke has a partitioned spring box which collects the flow of some thermal waters. The spring box consists of a 4.5 foot (inside dimensions) square concrete box approximately 5.5 feet deep and it is constructed over the main spring outlet. Adjacent to

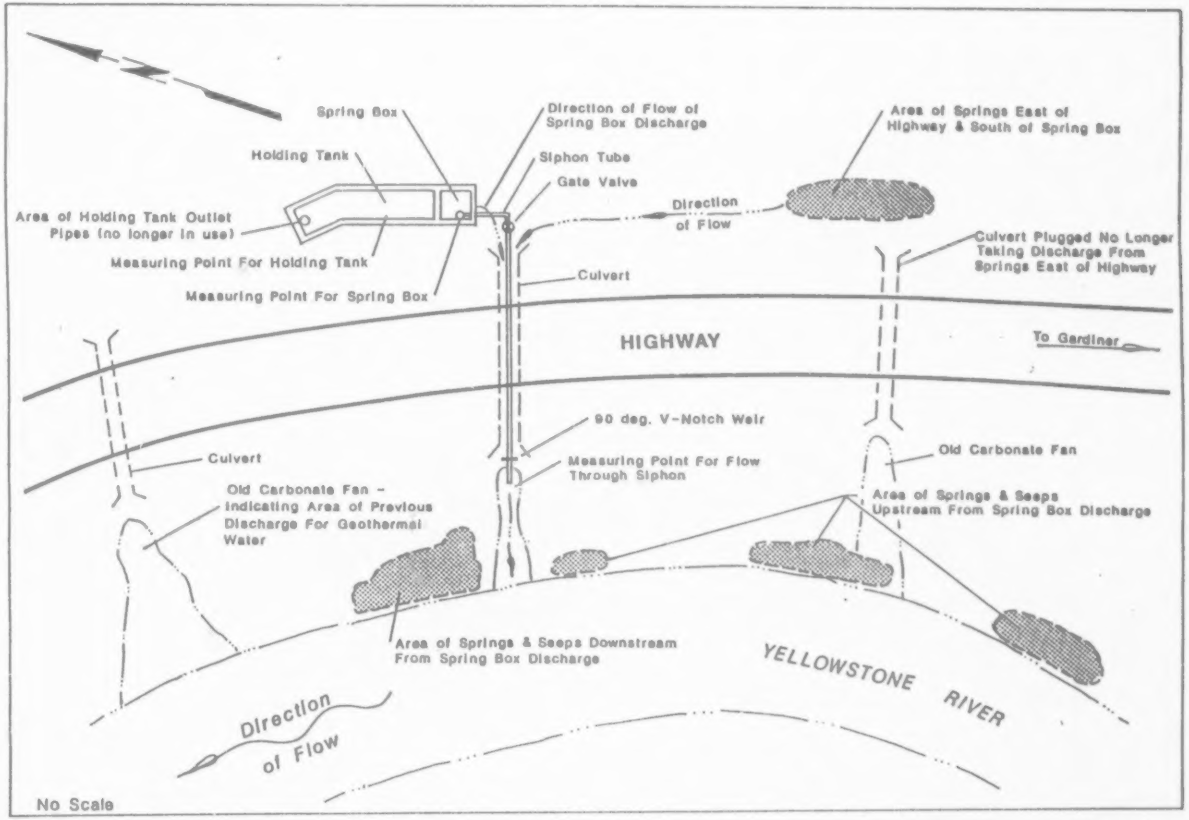

N
Spring Box
Holding Tank
Area of Holding Tank Outlet Pipes (no longer in use)
Measuring Point For Holding Tank
Measuring Point For Spring Box
Direction of Flow of Spring Box Discharge
Siphon Tube
Gate Valve
Direction of Flow
Culvert
Area of Springs East of Highway & South of Spring Box
Culvert Plugged No Longer Taking Discharge From Springs East of Highway
HIGHWAY
To Gardiner
90 deg. V-Notch Weir
Measuring Point For Flow Through Siphon
Old Carbonate Fan
Area of Springs & Seeps Upstream From Spring Box Discharge
Culvert
Old Carbonate Fan - Indicating Area of Previous Discharge For Geothermal Water
Area of Springs & Seeps Downstream From Spring Box Discharge
YELLOWSTONE RIVER
Direction of Flow
No Scale

Figure 1.
LaDuke Spring - Sketch Map

the actual spring box is a concrete holding tank which measures 60 feet long, 4-feet wide (inside dimensions) and 4.5 feet deep. The spring box and holding tank, which are contiguous, have a 1-foot thick concrete wall in common. Though not visible, there are openings at the base of the wall allowing flow between the spring box and holding tank. The spring box itself holds about 835 gallons when full. The holding tank has a maximum capacity of about 8000 gallons.

The present discharge occurs on the south end of the spring box where water cascades over the top of the spring box wall then into a culvert that goes beneath the highway. The original pipe outlet from the holding tank was on the north side of the holding tank away from the main spring box. The pipe went north and then went beneath the highway at a point about 265 feet north of the present point of discharge. Originally, the flow from the holding tank at LaDuke Hot Spring was piped to the Corwin Springs Hotel. In later years, the discharge went to the Yellowstone River at the roadway as evidenced by a carbonate deposit that fans outward to the river at the old discharge point. The old holding tank outlet appears to have been 3 to 4 feet below the top of the holding tank. In the past when water discharged from the old outlet, water levels in the holding tank are assumed to have been considerably lower than the present full condition. U. S. Geological Survey measurements of spring flow made in July 1975 and May 1976 were 132 gpm and 220 gpm, respectively (Hydrometrics, 1986). These measurements probably were made during the period that the old holding tank outlet was active.

## LADUKE HOT SPRING WATER PRODUCTION TESTS

Water production tests from the main spring at LaDuke Hot Spring were conducted on May 20 and 21, 1987. The production of water at different levels of drawdown in the spring box was tested by use of a siphon tube placed in the spring box and run through the culvert beneath the highway (Figure 1). The siphon tube discharged about three feet beyond a 90 degree, V-notch weir at the end of the culvert. Four-inch ID (inside diameter) PVC pipe was used for the siphon tube construction with a gate valve placed in the line 26-inches lower than the top of the spring box. This gate valve was used to control the flow rate of the siphon tube.

After completing installation of the siphon, water levels in the spring box and holding tank were drawn down until all discharge was confined to the siphon. The gate valve was then partially closed, the spring box and holding tank were allowed to equilibrate for about 38 minutes and the siphon discharge was measured. Drawdowns and flows from the spring are summarized in Table 1. After measuring the flow rate with the water level just below the top of the spring box and holding tank, the gate valve was further opened and the water level was drawn down during a three-hour period to 14.5 inches below the top of the concrete. The flow, at a spring box drawdown of 14.75 inches, was measured after the system had been allowed to equilibrate for one-half hour. The water level was dropped further during the next hour to 16-inches below the top of the spring box. During the following nine-hour period, the water level dropped 0.5 inches to 16.5 inches.

TABLE 1. MEASUREMENTS OF DRAWDOWN AND FLOW FROM THE LADUKE HOT SPRING SPRING BOX AND HOLDING TANK

| Date and Hour | Spring Box Drawdown below Measuring Point*/Temp | | Holding Tank Drawdown below Measuring Point**/Temp | | |
|---|---|---|---|---|---|
| | (inches) | (°C) | (inches) | (°C) | (gpm) |
| Opened Valve | | | | | |
| 5/20 15:45 | Overflow | 66° | 0.4 | 59° | - |
| 15:53 | 0.1 | - | 0.75 | - | - |
| 16:12 | 0.1 | - | 1 | - | - |
| Partially closed Valve (16:23) | | | | | |
| 16:50 | 0.1 | 66° | 1 | 59° | 64 |
| Opened Valve (17:34) | | | | | |
| 5/20 20:03 | 14.0 | 66° | 13.5 | 60° | - |
| 20:30 | 14.5 | - | 14.25 | - | - |
| Partially Closed Valve (20:31) | | | | | |
| 5/20 21:02 | 14.75 | - | 14.25 | - | 95 |
| Opened Valve (21:08) | | | | | |
| 5/20 22:06 | 16 | - | 15.75 | - | - |
| 5/21 07:00 | 16.5 | 66° | 16.5 | 61° | 105 |
| Opened Valve (08.06) | | | | | |
| 5/21 10:12 | 21 | - | 20 | - | - |
| 10:30 | 21.75 | - | 20.4 | - | - |
| 11:17 | 22 | 66° | 21 | 61° | 115 |
| Closed Valve Completely (11:24) | | | | | |
| 5/21 12:30 | Overflow | 66° | 0.75 | 61° | |

* Drawdown in the spring box is measured from the top of the west concrete wall 30 inches from the outside southwest corner. When overflowing normally, the water level is 0.5 inches above the top of concrete wall (0-measuring point)

** Measuring point for holding tank drawdown is 16 feet north of spring box measuring point. Zero point for measurement of drawdown is the fine edge of carbonate material built up on the side of holding tank indicating the water level during spring box overflow conditions.

Flow measurements were taken at 16.5 inches of drawdown. After this measurement, the gate valve was opened further and the spring box was lowered another 5.25 inches during the next 2.5 hours. During the next 0.5 hours the water level in the spring box dropped another 0.25 inches down to 22 inches. Discharge measurements were made at 22 inches and then the gate valve fully closed. Overflow from the spring box began 1.1 hours after closing the gate valve.

Flow measurements from the end of the siphon tube were made by using a 5.0 gallon bucket and stopwatch for the lower flow rates. Five separate buckets were filled for each measurement and the time taken to fill each bucket was determined with a stopwatch. In addition to using a bucket and stopwatch for flow measurements, the discharge also was determined from the siphon tube by measuring the horizontal distance needed for a specified vertical drop (Driscoll, et al., Groundwater and Wells, Second Edition). This technique was used for all flow rates. Prior to the drop measurements, the end of the pipe was carefully leveled with a four-foot long level. The discharge pipe was checked periodically to assure the pipe remained horizontal.

## SPRING FLOW MAPPING AND MEASUREMENTS

Mapping and evaluation of numerous small thermal springs within the area was done by Brunton compass and pace traverses. Initially, a series of stakes 100 feet apart were laid out using a 300-foot long tape. These stakes were for control of compass and pace work and marked the basic grid line points used in the river survey. Flow rates from springs were estimated, temperature measurements were obtained and the height above the river water level was measured.

River water temperatures were measured using a thermister probe that was cross calibrated with a mercury thermometer. Temperature readings were made for 5 different distances away from the edge of water out into the river along the established grid lines. Additional random thermister probing was done in a large boulder zone in the river that is upstream from the main LaDuke Hot Spring discharge area.

## RESULTS

### Spring Box Measurements

The siphon tube placed in the spring box showed that the amount of discharge of the spring is related to the water level in the spring box. The flow rate from the siphon with the water level just below the top of the spring box was measured at 64 gallons per minute (gpm). With the water level 14.75 inches below the top of the spring box, a flow rate of about 95 gpm was measured. At 16.5 inches of drawdown, a flow rate of 105 gpm was measured and at 22-inches of drawdown, a flow rate of 115 gpm was measured. Figure 2 shows the drawdown versus vs. flow rates from the spring. Projecting the straight line graph out to 36-inches drawdown (possible spring box water level when geothermal waters discharged out of north end of the holding tank), the estimated flow rate may have been about 150 gpm. This value is comparable to the U. S. Geologic Survey measurements obtained in 1975 and 1976 of 132 gpm and 220 gpm, respectively (Hydrometrics, 1986).

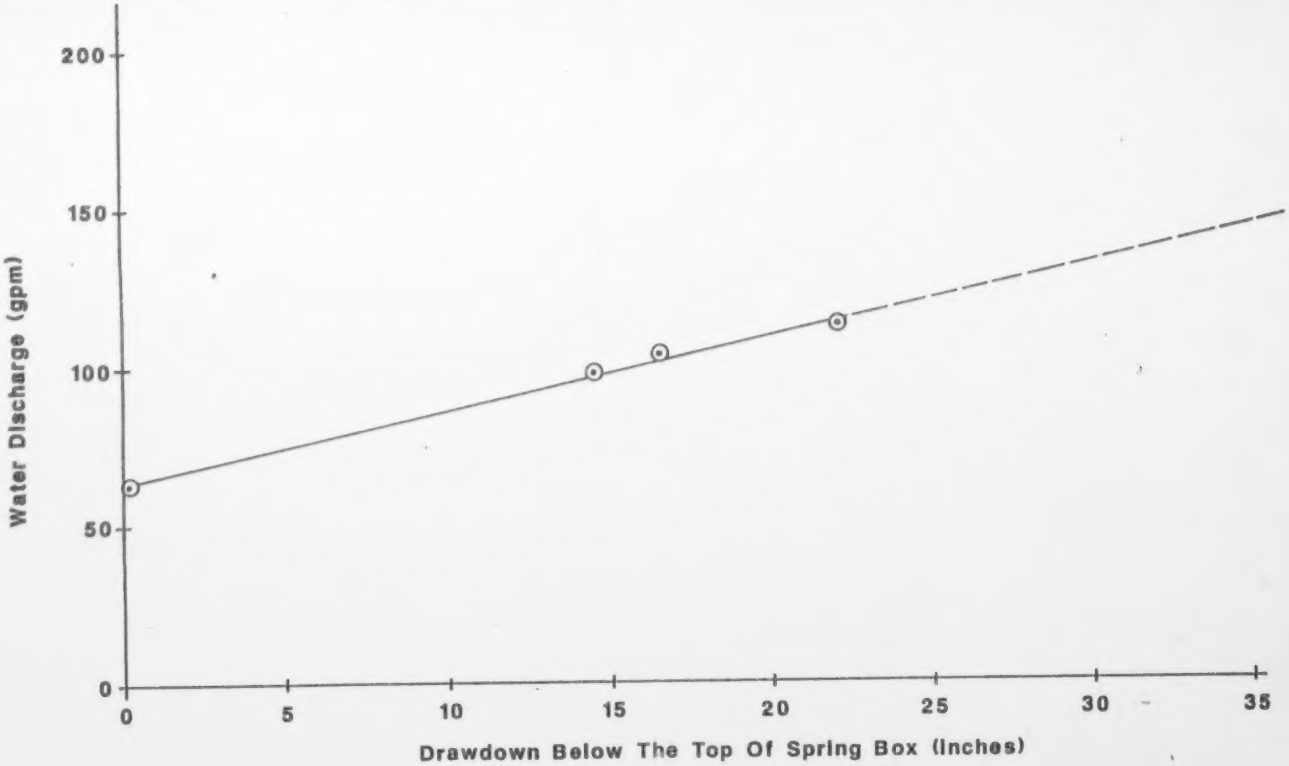


Figure 2.

Drawdown Versus Water Production
LaDuke Hot Spring, Park County, Montana

### Springs and Seeps

In addition to the spring box, 19 individual springs and 10 seeps were observed and the flows estimated for the springs (Table 2). Most of the observable springs and seeps are present in three general areas (Figure 1). These are:

1) Springs south of the spring box and east of Highway 89 which have a measured aggregate flow of 3.75 gpm.

2) Springs along the river bank upstream from the spring box. These discharge an aggregate of 4 to 5.3 gpm.

3) Springs present along the river bank downstream from the spring box. These discharge an estimated total of 3.2 gpm.

In total, the observable small springs and seeps are adding an estimated 11 to 12.5 gpm into the Yellowstone River in the LaDuke Hot Spring area.

The spring box discharge from LaDuke Hot Spring (about 65 gpm, 57° at point of entry) was increasing the river water temperature 2.5 degrees centigrade a distance of 0.5 feet from edge of water. Thermal water flowing into the river is rapidly diluted with river water. This precluded underwater thermal spring discharge detection except for large thermal flows or in areas where the inflow is not being rapidly diluted by river water. Possible springs and seeps beneath the river

## TABLE 2. SPRINGS AND SEEPS IN THE LADUKE HOT SPRING AREA

| Station (feet)* | | Feet Above River | Temperature (°C) | Flow (gpm Est.) | Remarks |
|---|---|---|---|---|---|
| | Upstream of Main Spring Discharge Along River Bank | | | | |
| South | East | | | | |
| 0 | 0 | 0 | 66** | - | Main Spring Discharge |
| 35 | 0.5 | 0.5 | 47 | .5-1 | Spring |
| 40 | 0.5 | 0.5 | 63 | 1.5-2 | Spring |
| 210 | 8 | 4 | 41 | - | Seep |
| 212 | 1 | 1 | - | .1 | Spring |
| 214 | 2 | 2.5 | - | .1 | Spring |
| 220 | 5 | 3 | - | .1 | Spring |
| 235 | 7 | 4.5 | 39 | .25 | Spring |
| 240 | 5 | 3.5 | - | - | Seep |
| 255 | 0.5 | 0.1 | - | - | Seep |
| 290 | 6 | 2 | 41 | .50 | Spring |
| 280 | 4 | 1.5 | 40 | .25-.33 | Spring |
| 305 | 7 | 4 | 41 | .25-.50 | Spring |
| 310 | 8 | 3 | 41 | .25-.50 | Spring |
| 585 | 4 | 1 | 31 | .25 | Spring |
| 615 | 8 | 1 | 25 | - | Seep |
| 640 | 4 | 1 | 31 | - | Seep |
| | Downstream of Main Spring Discharge Along River Bank | | | | |
| North | East | | | | |
| 20 | 15 | 4 | - | .5 | Spring |
| 25 | 10 | 12 | 64 | .5 | Spring |
| 30 | 8 | 8 | 64 | .5 | Spring |
| 36 | 3 | 9 | - | - | Seep |
| 40 | 4 | 4 | 63 | .75 | Spring |
| 43-50 | 4 | 3 | - | - | 3 Seeps |
| 60 | 6 | 3 | 58 | .75-1 | Spring |
| 260 | 35 | 15 | 46 | .2 | Spring |
| | | South of Spring Box - East of Highway*** | | | |
| SSB | | TSB | | | |
| 200 | - | 15 | 61 | 1-2 | Spring |
| 210 | - | 10 | 58 | .5-.75 | Spring |
| 240 | - | 10 | 40 | - | Seep |

* Point of LaDuke Hot Spring main flow entering Yellowstone River = 0 feet (North/South), 0 feet East, and 0 feet above river level.

** Temperature of water at point of river entry = 57°.

*** Springs east of highway (measured aggregate flows in a 90° V-notch weir is 3.75 gpm);
SSB = South of spring box (feet);
TSB = Feet above spring box.

water level went undetected with the exception of an area 200 feet upstream from the spring box discharge. In this area, a two degree centigrade increase in water temperature was detected in the boulder rubble next to the river bottom about 3 to 5 feet from the water edge. The possible thermal water inflow could not be estimated for this area. The boulder rubble appears to somewhat protect possible incoming thermal water from rapid dilution by river water.

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Hydrometrics, 1986. Aquifer Testing and Evaluation of a Geothermal Well at Royal Teton Ranch near Corwin Springs, Montana. A private report prepared by Hydrometrics for the Royal Teton Ranch, December 23.

# Informal Report to State of Montana Agencies

Department of Health and Environmental Sciences, and

Department of Natural Resources and Conservation

concerning

# Potential Effects of Production from a Geothermal Well located near La Duke Hot Spring

by

John L. Sonderegger
Montana Bureau of Mines and Geology

## 1.0 Introduction

The Montana Bureau of Mines and Geology (MBMG) was requested by two State agencies (DHES and DNR&C) to evaluate the impact of pumping a production geothermal well located adjacent to La Duke Hot Spring at 400 to 500 gpm, with particular emphasis upon effects in Yellowstone National Park (YNP). Using the available data, any evaluation must be qualitative in nature. The geologic constraints are reviewed below and the known hydrologic and water chemistry aspects discussed in light of the geologic framework.

## 2.0 Geologic Conditions

### 2.1 Introduction

The La Duke Hot Spring is located 1.65 miles north of Yellowstone National Park (YNP). YNP encompasses a caldera of Pleistocene and Recent age. The northwestern portion of the park contains outcroppings of older rocks of Paleozoic and Mesozoic age (U.S. Geol. Survey, 1972; Ruppel, 1972). Of particular interest are the limestones, especially the Madison Group, which are believed to be the primary reservoir for both Mammoth Hot Springs (in YNP) and La Duke Hot Springs.

### 2.2 Structural Setting

The Sepulcher Mountain graben (Ruppel, 1972) is a through-going structural trough bounded by the Reese Creek and East Gallatin faults on the west, and the Mammoth fault zone on the east. This graben is truncated to the north by the Gardiner fault zone which forms the southwestern margin of the Beartooth uplift (Foose and others, 1961).

Struhsacker (1976) has mapped the goelogy in the vicinity of the La Duke Hot Spring and integrated it with the work of Ruppel (1972) and Fraser and others (1969). Struhsacker (1976, figures 4 and 5) depicts the Gardiner fault as being extensively broken by the series of north-trending faults that created the Sepulcher Mountain graben.

The essential elements of this system consist of:

(1) The northern boundary formed by the northwest-trending Gardiner fault zone which consists of a master, high-angle, reverse thrust fault with associated shearing and relief faults (Fraser and others, 1969, p. 63-69 and plate 1) which may have had strike-slip movement, and has probably had continued movement occurring into Holocene time (ibid, p. 69).

(2) A pair of graben-bounding, north-trending fault zones, apparently younger than the Gardiner fault zone, which created the down-dropped structure.

Grabens are created by faults associated with extensional stress. Extensional faults commonly produce zones of enhanced secondary porosity.

## 2.3 Geological setting

The presence of young volcanic rocks and sediments covering the pre-Tertiary rocks has limited knowlege of deeper structures. Madison Group limestones are believed to be the reservoir rock for both the Mammoth and La Duke Hot Springs as their spring-water chemistry has a definite carbonate-host signature.

The rocks of Mesozoic age are clastic deposits with some calcareous cements and only minor limestone units (the "gastropod limestone", about 25 feet in thickness, in the Kootenai Formation, and the middle limestone member of the Sawtooth Formation, 60 to 75 feet in thickness; Ruppel, 1972). The first significant carbonate unit encountered below the land surface in the normal stratigraphic sequence is the Madison Group. Ruppel (1972, p. 60-61) includes a geologic section measured by Mapel and others in YNP which depicts a total thickness of 1300 feet of limestone and dolomite for the Madison Group.

The Madison Group outcrops on the west side of the Sepulcher graben on the sides of Quadrant Mountain, it is covered at lower elevations by glacial deposits. On the eastern margin of the graben the only outcrop is near Whiteroot Spring. However, exposures of Pennsylvanian age formations that immediately overlie the Madison Group (and which have a total thickness of less than 400 feet) along a northerly trend support the shallow subcrop of the Madison Group east of the graben margin and south of Bunsen Peak (Ruppel, 1972, plate 1, cross-section G-G').

Additional outcrops of the Madison Group occur about 10 miles east of Mammoth Hot Springs in the Gardiner fault zone (Ruppel, 1972, Plate 1). Appendix 1 contains figures from Ruppel (1972) and Struhsacker (1976) to help the reader visualize the geologic setting.

## 2.4 Synthesis

The eastern and western north-trending fault zones that bound the Sepulcher graben and the Gardiner fault zone, against which the graben terminates, are believed to be the major controlling factors for this geothermal reservoir. The extensional, graben-related faults are believed to be the major zones of recharge to the deeper carbonate aquifer.

Preferential dissolution of limestone and dolomite would be expected to occur adjacent to the tectonically developed secondary porosity, creating preferred avenues for groundwater movement. This enhanced porosity is the reason that locating high-yield well sites on fracture trace linements in carbonate terranes has been so successful (Lattman and Parizek, 1964). A carbonate aquifer (presumed to be the Madison Group) is thought to be the dominant "plumbing control" for the geothermal system.

Recharge to the system is believed to occur at altitudes above 7,000 (and probably above 7,200) feet above mean sea level, as post-Pleistocene travertine deposits at Mammoth occur up to a limit of 7,150 feet (White and others, 1975). The additional head differential would result from the density difference between "cold" recharge water and "hot" discharge water.

Discharge for this system is believed to start at the Mammoth Hot springs, continue at the Hot River springs, and finish at various locations along the Gardiner fault zone.

This interpretation differs from that of Struhsacker (1976) in that this author believes recharge occurs mainly along the margins of the graben rather than within the Gallatin horst or possibly as leakage from the Norris system.

## 3.0 Hydrology and Water Chemistry

### 3.1 Introduction

The key question, which cannot be answered definitely, is whether the Mammoth Hot Springs are hydrologically connected with the La Duke Hot Spring. The previous section briefly explained why, based upon the known geologic conditions, I believe that these low-temperature, carbonate rock

TABLE 1. CHEMICAL ANALYSES FROM SPRINGS, WELL AND RIVER [in mg/L unless otherwise indicated]

| Constituent | Mammoth[1] | La Duke Spring[2] | La Duke Spring[3] | La Duke Spring[4] | Hot River[5] |
|---|---|---|---|---|---|
| Ca | 272. | 320. | 342. | 316. | 106. |
| Mg | 68. | 58. | 63. | 72. | 69. |
| Na | 129. | 230. | 240. | 208. | 110. |
| K | 69. | 23. | 23. | 26. | 47. |
| Fe | 0.06 | 0.16 | 0.14 | 0.17 | — |
| Al | 0.2 | <.001 | <.1 | <.1 | — |
| $SiO_2$ | 55. | 49. | — | — | — |
| Li | 2.4 | 0.24 | — | — | — |
| $NH_4$ | 1.0 | 0.24 | — | — | — |
| $HCO_3$ | 667. | 300. | 278. | 229. | 96. |
| $SO_4$ | 501. | 1200. | 1340. | 1260. | 525. |
| Cl | 170. | 45. | 51. | 40. | 137. |
| F | 2.4 | 3.6 | 3.8 | 2.8 | — |
| $NO_3$ | 0. | — | 0.07 | <.05 | — |
| B | 4.3 | 0.46 | — | — | — |
| $H_2S$ | 2.6 | <1. | — | — | — |
| SC[6] | 2220. | 2460. | 2540. | 2410. | — |
| pH[7] | 6.6 | 6.5 | 6.7 | 7.0 | 8.05 |
| Temp[8] | 72. | 65. | 57. | 57. | 45. |

1. Mammoth analysis, 1955, listed on p. 54 of U. S. Geol. Survey Professional Paper 440F, except $SiO_2$ for which the value from White and others (1975) was used.
2. La Duke analysis, 1975, listed on p. 46 of U. S. Geol. Survey Open-File Report 78-438.
3. La Duke analysis, 1986, Appendix 3, Hydrometrics, 1986.
4. La Duke Well analysis, 1986, Appendix 3, Hydrometrics, 1986.
5. Hot River analysis at site YT23, 28 Sept., 1966, from U. S. Geol. Survey Open-File Report 75-25, provided by Rodney Hutchinson of YNP, author(s) unknown.
6. Specific conductance in micromhos/cm.
7. pH in standard units.
8. Temperature in degrees Celsius.

dominated, geothermal discharges represent one large system. This section provides additional support for that view and surveys the hydrologic consequences.

## 3.2 Water Chemistry

Table 1 presents previously collected chemical analyses of Mammoth and La Duke Hot Springs and the results for samples collected by Hydrometrics (1986) in conjunction with the aquifer test which they conducted. The major differences in water chemistry are greater sodium and sulfate concentrations at La Duke, which are somewhat compensated for by reduced potassium, bicarbonate and chloride concentrations.

These are both calcium dominated waters with substantial magnesium content. The differences in anion chemistry (bicarbonate-sulfate) is attributed mainly to interaction with anhydrite- or gypsum-bearing rock by the waters from the La Duke area. The water chemistry is compatible with a reaction path model in which waters, initially equilibrated with a dolomitic limestone, flow through a series of alternating gypsum- or anhydrite-bearing carbonate and reactive clays or shales--possibly in the Gardiner fault zone.

The Madison Group contains an evaporitic unit, the Charles Formation, at its top in other parts of Montana. It is not unreasonable for the top of the exposed Madison Group, a brecciated dolomite (Ruppel, 1972, p. 60), to be transitional to the Charles. The rationale for clay minerals being present is increase in sodium content down the proposed gradient with a simultaneous loss of chloride. The sodium increase is thought to have resulted from ion exchange reactions in which calcium, plus minor magnesium, lithium and ammonia replaced sodium on cation exchange sites of clays. The reduction in boron concentration also supports the interpreted presence of clays. Calcium and sulfate would be added to the water by the dissolution of gypsum or anhydrite. Most of the calcium is removed from the water via precipitation of calcite and ion exchange.

The chloride concentration difference indicates that a substantial portion of the thermal water currently discharging at the La Duke Hot Spring is from a considerably lower chloride-content source if the assumption of chloride conservation (i.e., that chloride takes part in no solid phase interactions and can be used for book-keeping purposes to calculate dilution) is valid. It is known that chloride will exchange with hydroxyl on clay-type minerals, but the differences in geothermal water chloride content require that, under the current hydrologic regimen, at least two-thirds and probably three-quarters of the water must come from recharge sources down gradient from the Mammoth Hot Springs.

## 3.3 Hydrology

There are substantial head differences between the geothermal discharge zones both within and outside of the Park: Mammoth ~6750 feet; Gardiner travertine ~6100 feet; Hot River ~5650 feet; and La Duke ~5280 feet. White and others (1975, p. 63) concluded (without citing reasons) that the Hot River thermal discharge "probably represents the subsurface discharge of most of the Mammoth system." Similarly, Struhsacker (1976, p. 67-69) links La Duke with the Gardiner travertine deposits and the Bear Creek spring (~5600 feet).

In the geologic analysis, it was suggested, because of the geologic structure and tectonic activity of this area, that the carbonate-rock dominated geothermal system be viewed holistically. The differences in elevation of the Mammoth and Hot River discharges within the Park (~1100 feet vertically over a horizontal distance of ~2 miles) requires formidable hydrologic barriers if the two discharges are related. Much of the difference between the Mammoth and Hot River water chemistries (Table 1) could be explained by the precipitation of calcium carbonate; however, the apparent head difference suggests that, at present, the hydrologic interconnection is very poor. True head measurements would require wells drilled to the reservoir zone to obtain pressure data from that zone. The current discharge locations within YNP lead to the conclusion that, at present, hydrologic discontinuities must exist within the carbonate-rock dominated geothermal system.

There are three erroneous or inconsistent statements in the Dec. 23, 1986 consulting report about La Duke that bear upon the hydrologic interpretation:

(1) La Duke is located only one and two-thirds miles north of the YNP boundary and is nine miles from Mammoth Hot Springs.

(2) The La Duke Spring has probably never produced 500 gpm. The 500 gpm figure cited as a U.S.G.S. measurement was instead a flow reported to the Montana Bureau of Mines and Geology (MBMG) coal geologist who collected samples from geothermal sources at the request of the MBMG's Director. There are no measurement notes in the file on this spring to support the discharge value as a measurement.

(3) The storage coefficient can be estimated by treating the spring as an observation well and the first time of measured flow reduction

(10%) as the time projection to zero drawdown. This value ($2.8 \times 10^{-3}$) is a maximum storativity based upon the assumptions, and indicates that the thermal source is at least semi-confined (a confined aquifer with leakage from other sources), and that effects of pumping can be transmitted for significant distances.

## 4.0 Conclusions

### 4.1 Introduction

As stated in the introduction, the response to the requst for an assessment of pumping impact from the recently drilled well near La Duke Hot Springs must be qualitative. Consequently, a best case/worst case analysis is presented.

### 4.2 Best Case

In this case the conclusions presented by Hydrometrics in their analysis are valid. Little or no impact from developing 400 to 500 gpm at La Duke would be noted in the park. This presumes that apparent hydrologic isolation is maintained under the hydrologic stress of removing as much as 210 to 263 million gallons (464 to 807 acre-feet) of thermal water per year at the La Duke well. This would constitute the capture of thermal water currently discharging along the Gardiner fault zone and any enhanced discharge would be compensated for by increased flow from a more northerly source than Mammoth thermal waters, of a low chloride content. An aerial, thermal-infrared imagery survey of the Yellowstone Rivers in the La Duke vicinity might permit an estimate of thermal discharge.

## 4.2 Worst Case

In this case the most scenic park feature related to the carbonate system (Mammoth Hot Springs) is isolated from the Hot River discharge and Mammoth waters are discharged along the Gardiner fault where it intersects with the Reese Creek fault—in the vicinity of La Duke Hot Spring. Initially only about one third of the pumped water comes from the Mammoth discharge, but, as pumping effects expand, a greater proportion of the water withdrawn comes from the Mammoth sector, and pressures decline causing some of the Mammoth springs to cease flowing.

This is feasible in a confined system. Geothermal aquifer testing in the Little Bitterroot Valley produced 0.1 feet of drawdown in a well 12 miles from the pumping point for a test that lasted 68 hours with an average production rate of 1400 gpm (Donovan, oral comm., 1987).

## 4.3 Concluding Observations

Because scenic features of a national park are potentially at risk, it would seem prudent to limit geothermal production in some manner and to assume, a priori, that any diminution of geothermal features with the Park's Mammoth area is a result of pumpage at La Duke. This would necessitate that the Park Service instrument, either for pressure or discharge measurements, or some of both, the Mammoth and Hot River springs. Additionally, limitations could be placed upon production at La Duke, by requiring that pumpage be adjusted such that the original "point of diversion", La Duke Hot Spring, maintains a small but measurable flow and that the chloride content of the thermal well water not exceed 50 mg/L (a value 25% greater than that reported for the well).

Limiting withdrawals from the existing well to the yield which does not quite dry up the La Duke Spring is particularly appealing because of its simplicity. It would require periodic sampling to verify that the spring is still yielding geothermal water, but it is a simple way to insure that excessive pressure reductions due to pumping do not occur. Additionally, while it will probably result in the production of a larger quantity of geothermal water than was discharging from the spring, it ties the production limit to the original point of diversion and all claims on that source.

## Appendix 1, Contents

1. Figure 18 from Ruppel (1972)
2. Figure 22 from Ruppel (1972)
3. Figure 4 from Struhsacker (1976)
4. Figure 5 from Struhsacker (1976)
5. Figure 8 from Struhsacker (1976)

stock probably is contemporaneous with the volcanic breccias on Sepulcher Mountain, which were dated as Eocene by Dorf (1960). The direct relation of early andesitic breccias and flows to laccoliths and sills as suggested by Hague (1896, p. 2) seems improbable, for eruption of the early volcanic rocks seems mainly to have been later than the principal movements on reverse faults, and the emplacement of laccoliths and sills seems to have been earlier.

### STRUCTURE

The faults and folds in the pre-Tertiary rocks of northern Yellowstone National Park (fig. 18) appear outwardly to have little relation to most faults and folds in surrounding areas, partly because comparatively little is known of the structural framework in much of the area immediately north of the park, but mostly because the park is in an unusual setting, where very different structural provinces come together. The earliest structural events involved the folding, intrusion by granitic magma, and metamorphism of the Precambrian rocks—in essence, several separate events that eventually converte both sedimentary and granitic rocks to the existin gneisses and schists. These periods of extreme de formation were followed by a long period of Pre cambrian time for which there is no record in th park. Presumably, the area was deeply eroded an furnished sediments to the Belt Supergroup rock that were being deposited to the north and west. A any rate, the Precambrian crystalline rocks had bee worn down to a nearly flat surface, littered wit quartz fragments, when the Flathead Sandstone o Middle Cambrian age was deposited. The Paleozoi and Mesozoic sedimentary rocks, lying in paralle beds, show that comparative structural quiet, broke only by repeated broad epeirogenic movements, continued until latest Cretaceous time, when the are was folded and faulted during a period of deformation that probably has not yet ended.

The faults in the northern part of the park ma be conveniently separated into (1) low-angle north-dipping faults, (2) northwest-trending high-angl

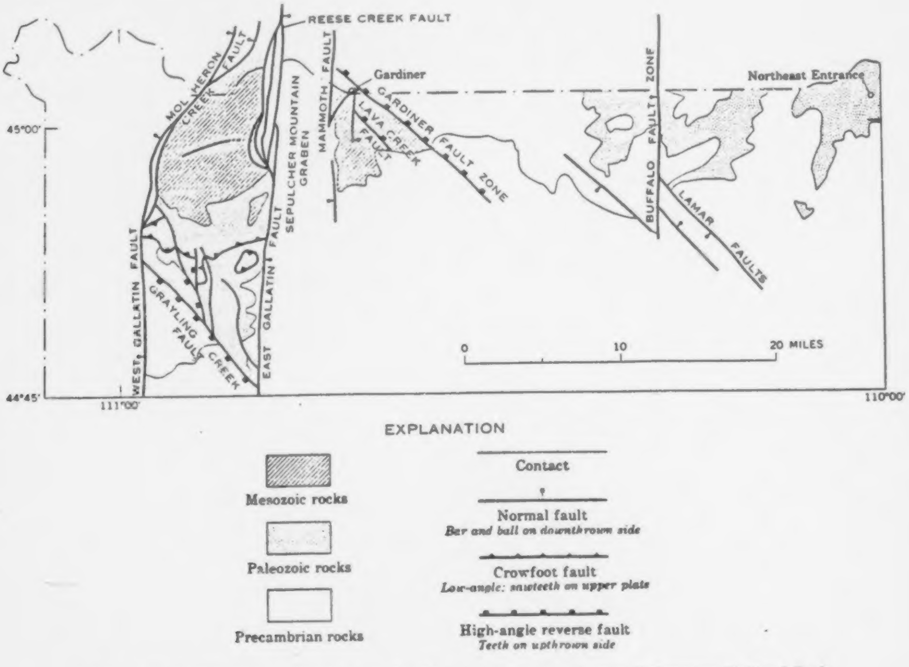
REESE CREEK FAULT
MOL HERON CREEK FAULT
MAMMOTH FAULT
Gardiner
GARDINER FAULT ZONE
LAVA CREEK FAULT
SEPULCHER MOUNTAIN GRABEN
BUFFALO FAULT ZONE
Northeast Entrance
LAMAR FAULTS
WEST GALLATIN FAULT
EAST GALLATIN FAULT
GRAYLING CREEK FAULT
45°00'
44°45'
111°00'
110°00'
0
10
20 MILES
EXPLANATION
Mesozoic rocks
Paleozoic rocks
Precambrian rocks
Contact
Normal fault
Bar and ball on downthrown side
Crowfoot fault
Low-angle; sawteeth on upper plate
High-angle reverse fault
Teeth on upthrown side

FIGURE 18.—Structural features in pre-Tertiary rocks, northern part of Yellowstone National Park.

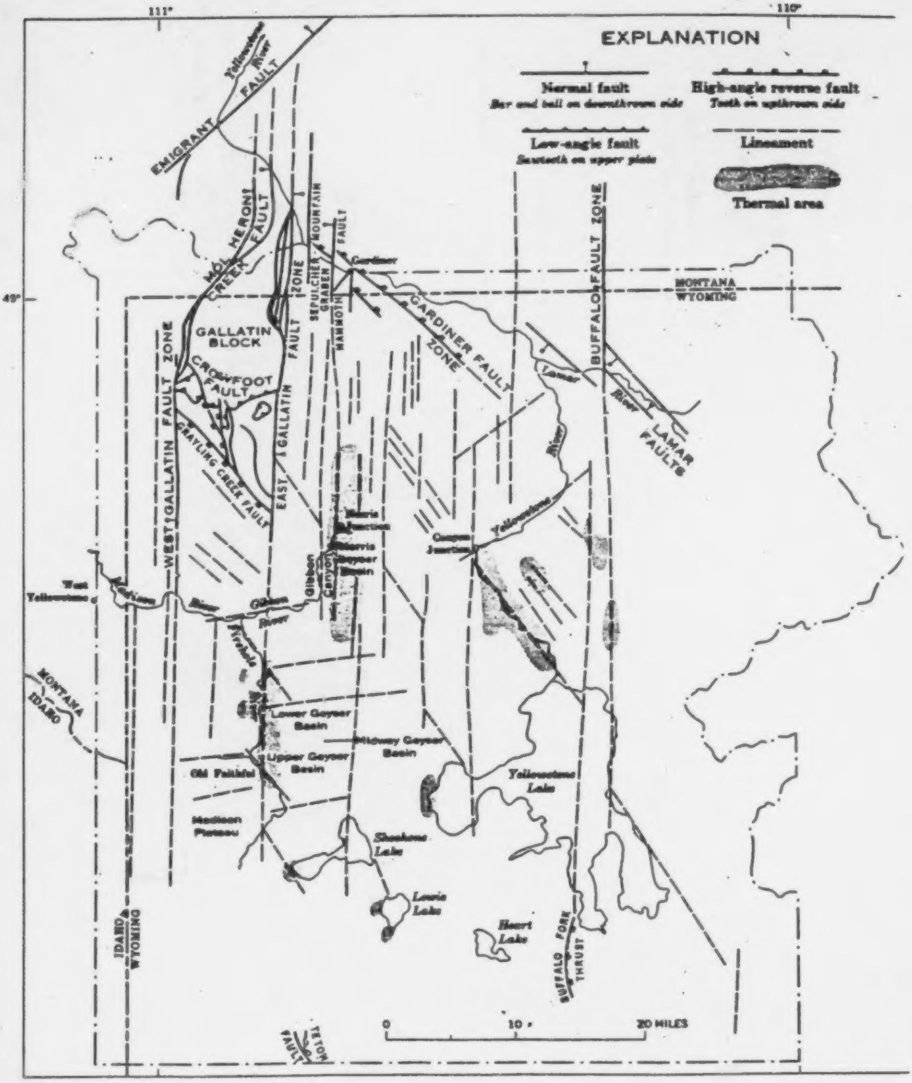
111°
110°
45°
EXPLANATION
Normal fault
Bar and ball on downthrown side
High-angle reverse fault
Teeth on upthrown side
Low-angle fault
Sawtooth on upper plate
Lineament
Thermal area
Yellowstone River
EMIGRANT FAULT
HOL HERON CREEK FAULT
SEPULCHER MOUNTAIN FAULT
GRABEN
MAMMOTH
Gardiner
MONTANA
WYOMING
GALLATIN BLOCK
WEST GALLATIN FAULT ZONE
EAST GALLATIN FAULT ZONE
CROWFOOT FAULT
GRAYLING CREEK FAULT
GARDINER FAULT ZONE
BUFFALO FAULT ZONE
Lamar River
LAMAR FAULTS
Norris Junction
Norris Geyser Basin
Gibbon Canyon
Canyon Junction
Yellowstone River
West Yellowstone
Madison River
Gibbon River
Firehole River
MONTANA
IDAHO
Lower Geyser Basin
Midway Geyser Basin
Upper Geyser Basin
Old Faithful
Madison Plateau
Yellowstone Lake
Shoshone Lake
Lewis Lake
Heart Lake
BUFFALO FORK THRUST
IDAHO
WYOMING
TETON FAULT
0
10
20 MILES

FIGURE 22. — Lineaments in part of Yellowstone National Park.

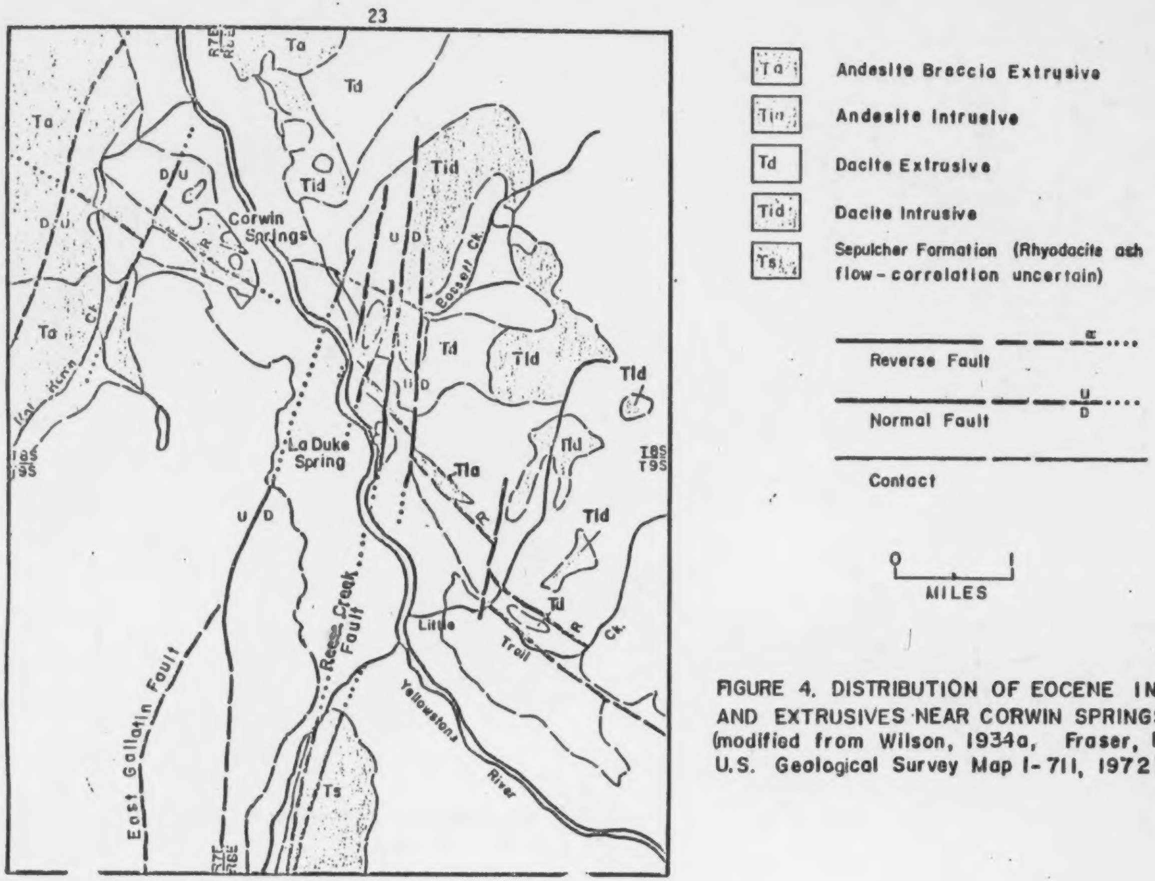
23
Ta
Td
Tid
Tid
Td
Tid
Tid
Tld
Tla
Tid
Tl
Ts
D U
D U
U D
U D
U D
R
R
R
Corwin Springs
La Duke Spring
Eccsell Ck.
Little Trail Ck.
Yellowstone River
Reese Creek Fault
East Gallatin Fault
R7E R8E
R7E R8E
T8S T9S
T8S T9S
Ta Andesite Braccia Extrusive
Tin Andesite Intrusive
Td Dacite Extrusive
Tid Dacite Intrusive
Ts Sepulcher Formation (Rhyodacite ash flow - correlation uncertain)
Reverse Fault
Normal Fault
U
D
R
Contact
0
1
MILES

FIGURE 4. DISTRIBUTION OF EOCENE INTRUS AND EXTRUSIVES NEAR CORWIN SPRINGS, MO (modified from Wilson, 1934a, Fraser, 1969, U.S. Geological Survey Map I-711, 1972)

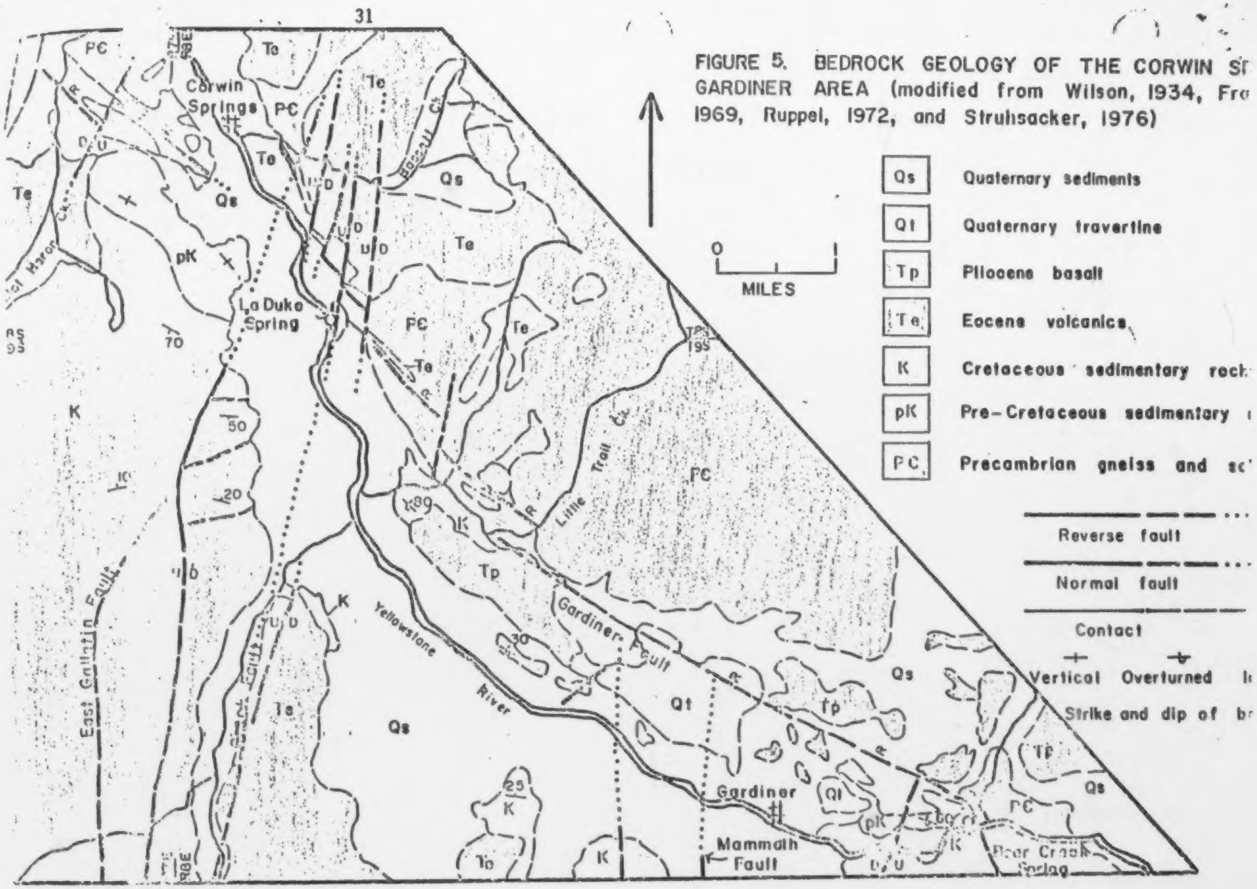
31
PC
Te
Corwin Springs
PC
Te
Qs
pK
La Duke Spring
Te
PC
Te
K
Little Trail Ck.
PC
195
Basalt Ck.
70
50
20
K
East Gallatin Fault
89
K
Tp
Gardiner Fault
30
Qt
Tp
Qs
Yellowstone River
Qs
Te
K
25
K
Te
K
Gardiner
Qt
pK
PC
Tp
Qs
Mammoth Fault
Bear Creek Spring
U D
MILES
0
Qs Quaternary sediments
Qt Quaternary travertine
Tp Pliocene basalt
Te Eocene volcanics
K Cretaceous sedimentary rock
pK Pre-Cretaceous sedimentary
PC Precambrian gneiss and sc
Reverse fault
Normal fault
Contact
Vertical Overturned
Strike and dip of b

FIGURE 5. BEDROCK GEOLOGY OF THE CORWIN S
GARDINER AREA (modified from Wilson, 1934, Fr
1969, Ruppel, 1972, and Struhsacker, 1976)

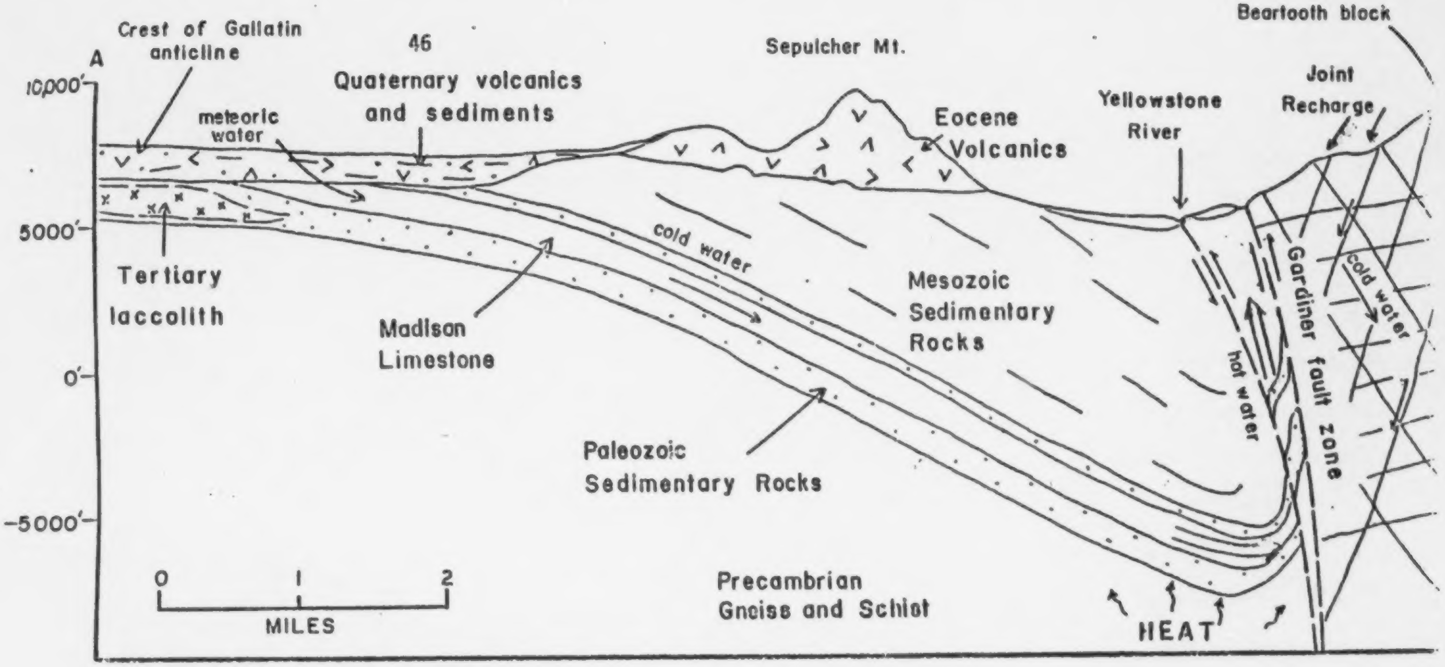
A
10,000'
5000'
0'
-5000'
Crest of Gallatin anticline
46
Quaternary volcanics and sediments
meteoric water
Tertiary laccolith
Madison Limestone
Paleozoic Sedimentary Rocks
cold water
Sepulcher Mt.
Eocene Volcanics
Mesozoic Sedimentary Rocks
Yellowstone River
Beartooth block
Joint Recharge
cold water
Gardiner fault zone
hot water
Precambrian Gneiss and Schist
HEAT
0
1
2
MILES

FIGURE 8. GEOLOGIC CROSS SECTION ALONG SEPULCHER GRABEN SHOWING POSSIBLE RECHARGE PATTERN FOR CORWIN SPRINGS GARDINER THERMAL AREAS (refer to Figure 2 for location of line A—A')

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Senator **Melcher**. Thank you very much, Mr. Francis. I noted that you are Vice President and Business Manager of Royal Teton Ranch.

That is how we have you listed on the witness list. But I believe you are more accurately the Vice President and Business Manager of Church Universal and Triumphant, as your testimony states.

Mr. **Francis**. Yes, sir. That is correct.

Senator **Melcher**. So your testimony here leads me to believe that you are speaking for the owners of the land and the owners of the development on church property there.

Mr. **Francis**. Yes, sir. That is correct.

Senator **Melcher**. Just for the record, how far is this well from the boundary of the park?

Mr. **Francis**. OK, it would be about 2 miles from the boundary of the park, and about 9 miles from the nearest geothermal feature inside the park.

Senator **Melcher**. Now, after the well was drilled across the river from, what is the spring, LaDuke?

Mr. **Francis**. LaDuke Hot Spring.

Senator **Melcher**. After the well was drilled, and tested at 400 gallons per minute——

Mr. **Francis**. About in that range; 400 to 500 gallons per minute.

Senator **Melcher**. The flow from LaDuke dropped from what, 50 some? It was not anywhere near 400 gallons. Was it?

Mr. **Francis**. Well, the flow of the spring was not actually measured at that time.

The measurements on the spring were based upon prior information that had been published by the USGS in a publication that they had that was entitled, The U.S. Geological Survey of Water Resources Data for Montana.

And they had measurements that varied from as low as 132 gallons per minute to as high as 500 gallons per minute in past years. We also had some measurements from the previous landowner, the owner of LaDuke Hot Spring, and the water rights there in the nature of about 500 gallons per minute, about 5 to 10 years previous to that.

The problem with the spring appears to be the fact that somebody has plugged one of the pipes that discharged from the spring, which caused it to fill up about 3 or 4 feet higher than would be normal.

And that evidently created an excess pressure on the spring discharge, which reduced the flow. The hydrologist went back in June and retested that, and he drew the level down in the spring box.

And he got the flow to increase to, in the neighborhood of about 150 gallons per minute. I have submitted a copy of that draft report of his to the subcommittee.

Senator **Melcher**. That is a draft report entitled, Aquifer Testing and Evaluation of the Geothermal Well at Royal Teton Ranch Near Corwin Springs, MT.

Mr. **Francis**. No. That is the first report. The draft report is entitled, Water Production Tests of LaDuke Hot Spring. And that was dated June, 1987.

Senator **Melcher**. And who prepared that?

Mr. FRANCIS. That was prepared by Maxwell Botts, of Hydrometrics in Helena, MT.

Senator MELCHER. I refer you to the summary, Mr. Francis. A thermal well was pumped for 13 hours at 400 gallons per minute to measure drawdown, and that is what we are talking about. Is it not?

Mr. FRANCIS. Yes, sir. It is.

Senator MELCHER. Also, they measured water quality and temperature to determine the effects of pumping on flow of LaDuke Hot Spring.

Pumping of the thermal well caused a rapid decrease in flow from LaDuke Hot Spring, with flow declining from 52 to 4 gallons per minute.

Now the reason I want to cite that is LaDuke Hot Spring is a free-flowing spring. Is it not?

Mr. FRANCIS. Yes. That is right.

Senator MELCHER. So you are drilling a well nearby.

Mr. FRANCIS. Right; 700 feet away.

Senator MELCHER. Seven hundred feet away. And when pumped at 400 gallons per minute in the test, it reduced the natural flowing hot spring to almost nothing, 4 gallons per minute. Well, nothing compared——

Mr. FRANCIS. Well, very low.

Senator MELCHER. Low, compared to 52, and extremely low compared to 4.

Mr. FRANCIS. Right.

Senator MELCHER. Now, as I read your conclusion here, in your testimony, speaking on behalf of the owners, the church, you are willing to forgo any further development of this well pending a study by the appropriate agencies?

Mr. FRANCIS. In Montana, the Department of Health and Environmental Sciences is conducting the EIS. However, we have not even actually applied for a permit to change the point of diversion on the LaDuke Hot Spring.

And that would be subject to the process carried out by the Department of Natural Resources and Conservation in Montana.

Senator MELCHER. Is the church willing to forgo any further development or pumping of this well pending the study that you mentioned by an appropriate agency, which you suggest with the USGS?

Mr. FRANCIS. You are suggesting a Federal agency examination of all of Yellowstone Park?

Senator MELCHER. I am suggesting, based on your testimony, and my understanding of what you are testifying, you say we would urge that Congress aid in this process of appropriate research and evaluation by providing appropriate direction and funding for a study.

And the next sentence says that you would recommend that it be done under the USGS.

Mr. FRANCIS. What I am suggesting here is, I am referring to the entire issue of geothermal leasing around Yellowstone Park. The issue of leasing around Yellowstone Park is many hundreds and thousands of times the volume of what we are talking about here.

The well that we have, and the discharge at LaDuke Hot Spring is miniscule, compared to leasing on Federal lands around Yellowstone Park. And what I am stating here is that I see a danger in the park resting on its laurels on what it now knows.

And I feel a study should be done whether or not any new leases made of lands around Yellowstone Park for Federal leasing, because of what could happen in the future.

Senator MELCHER. The only Federal leases involved or proposed around Yellowstone National Park for geothermal development were not in the park, and by law there can be no lease there.

Mr. FRANCIS. Some years ago there were some proposals made in the Corwin Springs area. There is an identified Corwin Springs known geothermal resource area. And there was some leasing activity proposed there also.

Senator MELCHER. Well, if it is necessary to guide prudent management of the Department of Interior, I suppose we will cite specifically other areas. I know of no contemplated or even dreamed-up application for a Federal lease for geothermal development other than in the park.

You mentioned Barbee's letter of an older date. You have, I assume, reviewed this, what was addressed to you, I am told, it was in May.

Mr. FRANCIS. Right.

Senator MELCHER. And of course you are aware of this recommendation. Now, getting back to my point, and my question.

Are you willing, is the church willing to forgo any further development or use of this well pending this study that you refer to?

Mr. FRANCIS. Well, sir, that question has never really been addressed to us. And I would not be in a position to respond to that standing right here, because I do not know what the study would be, how long it would take, what the conclusions—in other words, what the purpose of the study would be, how the conclusions would be framed.

At this point in time Yellowstone Park has probably a dozen studies in process on various things related to the geothermal resources on Yellowstone. However, none of them are couched in such as way as to yield conclusions that would be helpful on the point we are talking about.

Yellowstone Park conducts a lot of research, but they very rarely conduct research that is calculated to lead to conclusions of the sort that we are talking about here. I would very much support such a study.

And we certainly could agree to commit not to conduct any further geothermal exploration or drilling until such a study takes place, because we really do not plan to conduct any such geothermal drilling anyway.

However, in the case of LaDuke Hot Spring, it is in existing and historical use, and what we are talking about is getting to the point of proving exactly what the naturally occurring discharge is.

And then only withdrawing up to that amount of discharge as a maximum. As a matter of science, as a matter of hydrology, it is impossible to impact the aquifer if you are not withdrawing any more than it is already discharging itself.

Senator **Melcher**. That is why I referred you to the report of your consulting firm, when it said that LaDuke Hot Spring was a free-flowing spring at 52 gallons a minute.

Mr. **Francis**. That is why I referred you to the report in June, whereby simply drawing the spring box down a couple of feet, he has it going to 150 gallons a minute, and we have USGS measurements from past years at 132 and 220 gallons per minute.

Whatever the discharge is, if it is 50 gallons per minute, if it is 250 gallons per minute, or it is 500 gallons a minute, that will be our maximum.

The point is that we are pursuing our process with the State through the water rights adjudication process and through an environmental impact statement, and then through a permit process through DNRC that will establish quite clearly what that flow is.

It is a matter of disagreement at this point in time, but we expect to be able to get to the point that all parties will have an agreement on exactly what that flow is.

The other thing I wanted to point out is that right now around the spring there are all sorts of other discharges in the zone around the spring, about a 1,000-foot zone.

And we believe, and our hydrologist believes, that because of the raising of the head in the spring box by several feet, that it has caused more of that water to come out in the zone around the spring, because it is basically out of pressure at the time that it is coming out of the ground.

Senator **Melcher**. I do not imagine there are any of the historical deteriorations and destruction of the unique geyser basin that was done deliberately.

And I suspect that all of them, when they were destroyed, had the best judgment and consideration of those people who were drilling the wells that resulted in the destruction of the geyser basin.

I think the tone of your testimony, Mr. Francis, has been to be prudent and cautious. But however, in answer to my question of whether the church would be willing to forgo any further development, including the use of the well at any figure right now, until such a study as you recommended be done was completed, under the auspices of the USGS, you are not able to do that at this time, as I understand it, without a consultation.

Is that correct?

Mr. **Francis**. I think that is essentially correct. And frankly, based upon my past experience with the agency, I would want to know exactly what the study was going to be before I could agree to anything like that.

I am certainly not closing the door on it, but I would like to know a lot more before I could make any such tacit agreement.

Senator **Melcher**. Well, whatever, would you give us an answer to that on behalf of the church? And we will attach it to this record of this hearing.

Because I think I am very concerned your consulting firm has given you a worst case and best case scenario, and the worst case scenario fits in with the warning of Yellowstone Park Superintendent Barbee.

But the point is that the evaluation should be done with dispatch and should be done under the best sources that the Federal Government has, which is the U.S. Geological Survey.

And that requires time. It cannot be pushed through. It can meet no particular construction season or construction schedule. It takes time. And the evaluation, once made, should be guided by the most prudent advice from that evaluation, which may well urge and recommend that nothing be done with the well, period.

Or, if it is clearly demonstrated that this aquifer has no connection that can be ascertained at this time, at least that no more water be taken out other than what would be free-flowing from LaDuke Hot Spring.

Senator MELCHER. I am not going to be an expert in hydrology, and I well know how difficult it is to accurately describe what makes a geyser basin a geyser basin, and what is harmful to it.

My position is, if there is any chance of any harm that it should not be done, period. And that the uniqueness of this particular geyser basin cannot be taken lightly. It has to be protected, and we have to take every step that is essential to protect it.

Short of Federal direction on this, we only have existing law. Or short of new law, we only have existing law to fall back on. Existing law, as was referenced earlier by the witnesses from the Department of the Interior, does lead to some theory that existing law is adequate.

I am not comfortable with it myself. There have been more court cases. The *Cappehert* case. I do not know whether it was under the Organic Act of the national parks or what it was.

But that case did allow the Secretary great latitude in the development, and it affected private land.

Mr. FRANCIS. Which case was this, sir?

Senator MELCHER. Cappehert. I am not sure of the spelling.

Mr. FRANCIS. If I could, Senator.

Senator MELCHER. C-a-p-p-e-h-e-r-t.

Mr. FRANCIS. OK. If I could, Senator, I wanted to recommend that you also consider making the report from Mr. Sonderegger from the Montana Bureau of Mines and Geology part of the record.

Senator MELCHER. We will make it part of the record too. We have a copy of it, I think, which you provided.

Mr. FRANCIS. I have given you copies of all three.

Senator MELCHER. We will make that part of the record also.

Mr. FRANCIS. He is also actually the one who gave the best case-worst case scenario.

Senator MELCHER. Did your hydrologist, your consulting firm, give you a worst case-best case scenario?

Mr. FRANCIS. No. Because the existing literature on the subject runs against what the Superintendent of the park had to say, and what Sonderegger's worst case said.

However, he certainly admits that there is a relative lack of hydrogeological information available on the subject. However, the indication is geologically that there is a discontinuity between the region in the park and the region north of the park. But that is what his conclusions are based on.

I wanted to simply point out that Sonderegger's report gave the best case and worst case scenario. Assuming the worst case to be true, he was the one who also pointed out the method for ensuring that the aquifer was not damaged and that no additional draining could occur from the park, even if there were a hydrologic connection, and that is to maintain at least a small but measurable flow from LaDuke Spring, regardless of what level of use we make.

Senator **Melcher**. Well, let me remind you again, Mr. Francis, that the worst case has happened in almost all of the premier, unique geyser basins around the world.

The last remaining unique, great geyser basin of the world is Yellowstone, that geyser basin. So the world has witnessed the worst case scenario, and what we have left at Yellowstone we would like to protect. And prudence will have to guide us in protecting that.

I personally respect property rights of landowners. I believe it is very important that we do. But in the public interest, there are occasions when we have to hamper the right of a property owner. And this may be one of them.

I would like your cooperation as we go through the next few months or next year to make sure we are acting prudently.

Mr. **Francis**. Senator, I have pledged our cooperation to Superintendent Barbee. And you certainly have our cooperation. We are not pressing ahead with this with any dispatch whatsoever.

We are easily still several years away from any kind of taking, any kind of further action here. And I simply also wanted to point out that we are very aware of the fact that damage has taken place in other parts of the world.

However, I wanted to state for the record that I have had personal conversations with individuals from the Bureau of Land Management, the office of fluid minerals, who have stated to me unequivocally that they disagree with those conclusions, not in every case, but in many cases, that the damage has occurred every place as they have stated.

And that furthermore, basically what they have said was that the damage that has occurred is in places where they went in and exploited and drilled wells right next to geysers or within a half mile.

We are probably 20, 30 miles, 40 miles maybe even, from the nearest geyser area. And again, if any indication to us or the State or to our hydrologists or to any responsible person that is qualified, stating that they felt that our use of the well was simply unreasonable, we would not do it.

And I feel that if you look at Superintendent Barbee's letter carefully, I think you will notice that his reservations are based on a level of 400 to 500 gallons a minute, which is also based upon the disputing of that figure as an accurate measurement.

And we are certainly aware of the fact that that is a disputed figure. We are not sticking on the 400 to 500 gallons a minute. The only thing that we are looking at is the historical discharge and less.

So I feel that this is something that can, over a period of time, through cooperation with Yellowstone and the State agencies involved, it is something that can be resolved.

Senator **Melcher**. First of all, we only see Barbee's letter as a letter of a park superintendent, not as a letter of an expert.

Mr. **Francis**. Right.

Senator **Melcher**. We only see Barbee as reciting some of the prudent guidance that might be necessary to avoid making a mistake.

We have not made it part of the record. I am going to date this May 10, if that is an accurate date, because there is no date.

Mr. **Francis**. The one I had actually had the date stamped on it.

Senator **Melcher**. I will make this one part of the record.

Mr. **Francis**. The one I received from him actually had the date stamped on it. I think what they do is when they send those out, they stamp them.

Senator **Melcher**. May 10?

Mr. **Francis**. Yes, sir.

Senator **Melcher**. May 10 is the accurate date then. Thank you very much. And thank you for your testimony.

Mr. **Francis**. Thank you, Mr. Chairman.

[The text of Superintendent Barbee's letter follows:]

United States Department of the Interior
NATIONAL PARK SERVICE
YELLOWSTONE NATIONAL PARK
WYOMING 82190

IN REPLY REFER TO:

N3039(YELL)

May 10, 1987

Mr. Edward L. Francis
Church Universal and Triumphant
Box A
Corwin Springs, Montana 59021

Dear Ed:

We have reviewed your letter of January 15, 1987, and the report "Aquifer Testing of a Geothermal Well at Royal Teton Ranch Near Corwin Springs, Montana," prepared by Hydrometrics consultants on December 23, 1986, evaluating your geothermal well near La Duke Hot Spring. We offer comments, corrections, and concerns based on the professional opinion of our staff. In several instances, original information was brought to our attention through outside review by professional geoscientists representing disciplines complementing those we have locally.

As a result of this analyses, and until any new facts indicate otherwise, our position is thus:

1. La Duke Hot Spring and your drilled well near Spring Creek intercept the same aquifer.

2. This aquifer is, or is substantially recharged by geothermal fluids within the Gardiner fault zone and closely associated faults.

3. Within the Gardiner fault zone and closely associated faults, continuity exists with an interconnected network permitting water flow in narrowly confined zones across the boundary of Yellowstone National Park.

4. The same geothermal reservoir may supply geothermal springs within Yellowstone as well as La Duke Hot Spring, or multiple reservoirs may be interconnected deep within the earth.

5. Drawdown distribution analysis using data in the Hydrometrics Report shows that aquifers may be affected at a distance of 9.5 miles from the well after only 30 days of pumping at 400 gpm.

6. There is apparently no solid evidence (measured flows) to suggest La Duke Hot Spring ever had an output as high as 500 gpm, and actual flows appear to be only one-fifth that amount, therefore, extracting

the larger amount from your well would instantaneously begin to deplete the aquifer.

7. Substantial evidence from other geothermal fields worldwide has consistently shown the deleterious effects of well development on nearby geysers, hot springs, and fumaroles.

Therefore, it is our view that the planned development of your geothermal well as outlined in the Hydrometrics Report would pose an unacceptable risk to geothermal features in Yellowstone National Park.

In your letter and in other public statements you have said that as long as you did not pump more water than naturally flows from La Duke Spring, the aquifer could not be damaged. If we assume you were correct in that reasoning, then the issue of the spring's output becomes critical.

We appreciate the sentiment expressed in your letter which stated "...we have pledged that if any detrimental impacts on Park geothermal features occur which are attributable to our use of the well, we will stop pumping." Our concern with your well-intentioned statement lies in the fact that other geothermal fields have experienced a considerable lag between the time of development and resultant damage. The lag time may be sufficiently long to allow the use of the fluids to become an established tradition with resultant dependant economies and there are inevitable high capital investment expenditures involved. In such cases there is typically great resistance to shut-down and the natural geothermal field usually ends up the loser. Even if a shut-down occurs, the damage to the thermal system is not necessarily reversible.

We have attached a more lengthy summary of the reasoning that caused us to adopt our position. If you have any questions regarding our position or this response, please feel free to contact us.

Sincerely,

Robert D. Barbee
Superintendent

Enclosure

cc:
Jim Melstad
Montana Department of Health
and Environmental Sciences
Water Quality Bureau
Cogswell Building
Helena, MT 59624

M. K. Botz, P.E.
Hyrdometrics
2727 Airport Road
Helena, Montana 59601

Comments of Yellowstone National Park concerning the study entitled "Aquifer Testing and Evaluation of a Geothermal Well at Royal Teton Ranch Near Corwin Springs, Montana"

April 1987

1. There is no geothermal development in the world within a geyser basin area that has not had adverse effects on the geyser. Geyser Valley in New Zealand was destroyed as a natural discharge area when the geothermal area was developed. Before this action, that valley ranked fifth among the major geyser areas of the world. In addition, production at Wairakei also affected another thermal area thought to be independent without any connection at depth which would simultaneously affect the pressure of both systems. As a result, both areas have been destroyed as resources and as reference lines for understanding the hydrothermal system. The geyser area of Nevada was once second to Yellowstone on the North American Continent in the 1940's and 1950's when geothermal exploration was begun. Wells were drilled and permitted to discharge but not converted to commercial use. By 1961, all springs and geysers had ceased flowing. Similar destruction of the geyser area at Steamboat Springs, Nevada, occurred after geothermal exploration between 1950 and the early 1960's.

   Of the ten world geyser areas, only three, including Yellowstone, are essentially undisturbed. Four of the ten have been adversely affected by man's activities, and at least three of the major areas and several minor ones have seen the total destruction of their geysers.

2. Distance alone does not support the argument of no impact from the geothermal well on Yellowstone. In New Zealand, geothermal development wells have greatly reduced geyser activity and hot spring discharge up to a distance of at least 2.5 miles. In Iceland, hydrologic connections have been demonstrated within a volcanic caldera where initiation of flow on a geothermal drill hole produced almost instantaneous drawdown in a borehole 6.2 miles away. In Wyoming's Thermopolis Hot Springs State Park there is an apparent 20 percent decrease in hot water discharge coincident with recent geothermal drilling within 12 miles of the park boundary.

   With a development record such as this worldwide, you can understand our concern because an unnamed thermal spring is located near the Reese Creek fault within Yellowstone Park only 3 miles southwest of La Duke and internationally reknowned geothermal features are only 8.3 miles away.

Based on current research it appears the Reese Creek fault interconnects with the Gallatin fault zone, which is thought to conduct thermal waters north of Norris Geyser Basin.

3. We note on page 9 of the report that "Potential impacts to more distant water sources including geothermal features in Yellowstone Park are essentially impossible to assess due to the very limited understanding of hydrological systems and geological characteristics in the area." This statement is in sharp contrast to statements on pages 12-14 (e.g., "This large distance and difference in elevation makes it quite unlikely that hydraulic impacts from pumping could be transmitted to Yellowstone Park").

   We feel this is a discrepancy within the report itself. We are more in agreement with the opinion given on page 9 than that on page 12. Moreover, as noted below, based on our evaluation of current "understanding of hydrological systems and geological characteristics of the area," we are persuaded to the more conservative view; that pumping of 400-500 gpm (gallons per minute) from this well may cause a perceptible change in discharge at thermal springs in Yellowstone National Park. This opinion is based on three factors:

   a. Originally it was our understanding that the well would be pumped at only 100 gpm or less, an amount more in keeping with the present La Duke flows. Now you are proposing four to five times that amount, and considerably more than the natural La Duke flows.

   b. We have evidence that earlier reported flow rates at La Duke listed on page 46 are highly inaccurate and may have never been actual measurements. Noting that the La Duke flow was only 52 gpm at the beginning of the well test, we conclude that pumping in excess of that amount will draw the aquifer down.

   c. We infer that the La Duke discharge may derive from flow within fault zones in the area. Field observations are consistent with that inference. Computer modeling of drawdown distributions (King, 1970) in such a system using data from the Hydrometrics report shows that pumping at 400 gpm for only 30 days produces almost 2 feet of drawdown at a distance of 1.9 miles and a perceptible drawdown at 9.5 miles.

4. The Hydrometrics report does not seriously consider or evaluate long-distance transport of thermal waters in fault zones. U.S. Geological Survey researchers find evidence for transport of hot water at depth from the Norris area to Mammoth Hot Springs and beyond (Truesdell and Kennedy, 1986). This finding is in contrast to the largely theoretical conclusion of Struhsacker (1976) represented in Figure 10 of the report.

5. On page 5 we note that Hydrometrics' data do not permit calculation of the time to recovery of undisturbed flow at La Duke after pumping stopped at the well. The data presented do show that recovery time exceeds 12 hours at a distance of only 700 feet after a short test (13.35 hours). A normal standard test would last for 72 hours, but we do not recommend it because it might irrecoverably alter conditions at La Duke Hot Springs.

6. Silica, lithium, boron, and stable isotope data are not listed with the 1986 Hydrometrics data for waters from the well and La Duke Hot Spring. These elements and oxygen, hydrogen, carbon, and sulfur isotope measurements would be needed in order to better assess the question of source. With these data in hand, comparisons could be made with other nearby thermal features. The report does not address the question that La Duke water could be Hot River water that has reacted with gypsum in Cretaceous strata north of Mammoth Hot Springs.

7. There are several other miscellaneous points we wish to offer. Some are substantive and some are likely just typographical errors.

   a. We note that point 2 on page 13 ignores probable interconnection between the Gardiner fault and other mapped faults within Yellowstone National Park.

   b. The 500 gpm figure given in point 3 on page 13 is an estimate, not a U.S. Geological Survey measurement, and is probably in error.

   c. The conclusion in point 4 on page 13 does not logically follow from the sentence preceding it.

   d. On page iv we note that La Duke Hot Spring is 1.6 miles north of Yellowstone National Park, not 10 miles.

   e. On page 1 we note that the highway number is 89, not 87.

   f. The largest hot spring in the northern portion of Yellowstone is Hot River, located only 8.3 miles southeast of La Duke, not 10 miles south as stated on page 3.

References:

King, J. M., 1984, Field Reports - computing drawdown distributions using microcomputers, Ground Water, v. 22, No. 6, pp. 780-785.

Truesdell, A. H., and B. M. Kennedy, 1986, Yellowstone before (and after) RARGA, Presented at Japan - U.S. Seminar on Terrestrial Rare Gases in Mammoth Hot Springs, Yellowstone National Park, September 3-6.

Senator **Melcher**. Our next witness is Mr. Henry T. Snow, Vice President and General Representative of Unocal Geothermal Division.

We do have three others representing companies that develop geothermal resources. Would you all like to approach the witness table at one time?

Mr. Bernard H. Cherry, President of Oxbow Geothermal Corporation, Mr. Domenic Falcone, Senior Vice President for Finance of Geothermal Resources International, San Mateo, CA, and Mr. Les A. Darling, Government Affairs Coordinator for Chevron Resources Company, of San Francisco.

I will mention this right now to all of you gentlemen, and also for Mr. Francis, that we will probably have additional questions. We will submit them to you and ask for you to respond to them. And we will make it part of the record too.

In the order that I named, Mr. Snow, then Mr. Cherry, Mr. Falcone, and Mr. Darling. Please summarize your testimony.

## STATEMENT OF HENRY T. SNOW, VICE PRESIDENT AND GENERAL REPRESENTATIVE, UNOCAL GEOTHERMAL DIVISION

Mr. **Snow**. Mr. Chairman, my name is Henry Snow. I am the Vice President and General Representative of the Unocal Geothermal Division.

I have heretofore submitted a written statement, which will be placed in the record. However, now I would like to just very briefly outline and emphasize two or three of the points in my statement.

First, geothermal is a proven alternative energy resource. The Geysers, which is the largest geothermal field in the world, presently has the capacity of 1,800 megawatts, which equates to 19 million barrels of low sulfur fuel oil per year that does not have to be burned in a boiler for generating electricity.

Second, geothermal energy is clean and safe. And third, experts contend and believe that there is at least 20,000 megawatts of generating capacity that can be developed in the West during the next two decades.

If this does happen, then that would equate out to 700,000 barrels of oil per day that would be saved. But today the geothermal industry is reeling from the so-called energy glut.

Falling prices, coupled with the cost of exploration and drilling, have placed the industry in a near noncompetitive position in the search for new resources. We believe this is a temporary situation and we believe that prices for energy will rise in the future.

But in the meantime a number of geothermal companies have reduced their activities or completely gone out of business. One of the reasons for this besides the current energy glut is the effects of certain provisions of the current Geothermal Steam Act of 1970.

The prime functions of the act which hinder the industry today is a well-producing or capable of producing geothermal steam in commercial quantities and must be completed before the end of the 10-year primary term and before 15 years from the beginning of the primary term. The operator must enter into a bonafide sales contract with a utility for the construction of a powerplant.

Now today, in the energy glut, we, the operators, are having difficulty in persuading private utilities to negotiate new sales contracts. In fact, we also have difficulty in persuading the utility companies to transmit and fill the transmission lines from these new fields.

Finally, the geothermal resource is merely the first stage of development. After sufficient resources are proven it is necessary to contract with the utility. Now, unlike the oil, gas, and coal industries, we have to build the powerplant within two miles of the wells.

We can not transport our products to market by truck or pipeline or barge or whatever. So we are restricted in who we can enter into sales contracts with.

Another problem in the current Geothermal Act is the short period of time in which we can develop our field even under the best case conditions. It takes 7 to 10 years to put a geothermal lease on production.

Now, the way your S. 1006 is presently written, we think this would eliminate a number of these problems. So therefore, on behalf of Unocal Corporation, we urge the enactment of this bill. Thank you.

[The prepared statement of Mr. Snow follows:]

STATEMENT OF HENRY T. SNOW

VICE PRESIDENT AND GENERAL REPRESENTATIVE

UNOCAL GEOTHERMAL DIVISION

BEFORE THE

SENATE SUBCOMMITTEE ON MINERAL RESOURCE DEVELOPMENT

AND PRODUCTION

OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES

WASHINGTON, D.C.

JULY 14, 1987

My name is Henry Snow. I am Vice President and General Representative of the Unocal Geothermal Division. I am here today to support and urge the rapid enactment of S.1006 which will promote the development of geothermal energy.

Before presenting the reasons for supporting this legislation, I would like to offer a few facts about the potential of geothermal energy, the contributions it can make to our Nation's energy requirements, and Unocal's efforts to develop this important energy resource.

On a nationwide scale, experts believe that there is a geological opportunity to produce enough geothermal energy to supply 20,000 megawatts (MW) of generating capacity in the next two decades. That is the equivalent of about 700,000 barrels of oil per day, or 8.5 percent of today's crude oil production in the United States. As the industry makes further technological advances, there is the potential for significantly increasing this capacity in succeeding decades.

Let me offer an example of the kind of growth I am referring to. Unocal is the principal operator of the Nation's major geothermal development at The Geysers in Sonoma and Lake Counties, California. The Geysers is the largest geothermal project in the world. Its development began in 1957, and, initial developments were slow, but today, enough steam is produced to power a generating capacity of approximately 1,800 MW. This is sufficient to supply all the electrical requirements of a typical city of almost two million people. Such generating capacity will result in a savings of about 19 million barrels of low sulphur fuel oil per year, which will not be needed to generate electricity. While growth at The Geysers was slow at the outset, we made faster progress as we made technological advances. Even today, continued expansion is taking place at The Geysers, and ultimate capacity is now estimated to be about 2,000 MW.

Unocal has long been a leader in the geothermal industry. We are responsible for approximately 1,800 MW of generating capacity worldwide; and we are planning to add another 210 MW, for which we have confirmed reserves. We are actively engaged in other projects here in the United States and abroad.

In the United States, in the Imperial Valley of southeastern California, Unocal has a project at the Salton Sea. Here we produce geothermal energy from the Valley's highly saline geothermal fluids to power a 10 MW generating plant, which is owned by Unocal's subsidiary, Earth Energy, Inc. This plant is the first in a series, which could eventually supply geothermal energy to generate several thousand megawatts of power for Southern California.

The Imperial Valley has often been called the Saudi Arabia of the world's geothermal resources because of its vast potential. Success with the initial Salton Sea endeavor will augur well for a stronger geothermal role in electrical generation in this fast-growing and populous section of the United States.

In addition, we currently have active or planned exploration activity elsewhere in California and in other western states. Unocal historically has a strong dedication to the development of geothermal energy, and we are committed to its future growth.

We support passage of S.1006, which was introduced on April 9, 1987 by Senator Hecht. It is a significant piece of legislation in and of itself. But, with the current energy situation, it is especially important. The geothermal industry is reeling from the so-called energy glut. Falling prices coupled with the cost of exploration and drilling have placed the industry in a near noncompetitive position in the search for new resources.

We believe the current energy situation is temporary and that demand and price for energy will rise in the future. The need for alternative energy in general and geothermal in particular will be reignited. Therefore, it is imperative that the search for geothermal resources continue during this downward swing in industry activity. Instead, what is happening is that more and more companies are going out of business or reducing or abandoning their geothermal activities.

One of the causes of the reduced geothermal effort other than the above-mentioned economic condition, is a section in the Geothermal Steam Act of 1970, which requires a lessee to meet certain conditions at the expiration date of the primary term of a Federal geothermal lease or the lease will be cancelled. These conditions are as follows:

1. A well producing or capable of producing geothermal steam in commercial quantities.

2. A bona fide sale of such geothermal steam for delivery to or utilization by a facility or facilities not yet installed, but scheduled for installation not later than 15 years from the date of commencement of the primary term of the lease.

These conditions impose both a hardship and a deterrent to exploration and production of geothermal resources in today's market place. Geothermal operators are faced with public and private utilities that are not interested in negotiating new sales contracts. The utility industry in the western states generally has a surplus of power and seems unwilling to make capital investments for additional generating capacity or to expand existing transmission capacity. For example, we are an active member of an industry group funding the construction of a 230 kv transmission system to bring power from the Imperial Valley into Southern California, an activity normally financed and constructed by utilities.

This tends to discourage exploration for geothermal resources, particularly in remote areas of the west, since geologic success could cause economic failure. That is, if an operator invested huge sums of capital in exploration and made a discovery, but was unable to market the resource, his lease would terminate and his investment would be lost.

The geothermal industry is unlike other sources of energy such as oil, gas, and coal. The geothermal industry is still in its infancy and the technology for geothermal development and production is still being researched. When one drills a geothermal well, it is usually into extremely hard ignatious rock; and, in hot water wells, the fluid produced is very corrosive and hostile. All of this requires special equipment which has to be developed while one holds the lease. For example, in the Imperial Valley the fluid produced destroys stainless steel drilling pipe, and we are presently using titanium drilling pipe, which cost in the neighborhood of $1,000 per foot, while we search for a less expensive solution.

The discovery and production of the geothermal resource is merely the first stage of development. After sufficient resources are proven, it is necessary to negotiate a contract with a utility which will buy the steam and build a power plant to generate electricity. Since the steam from a geothermal well can not be transmitted more than 2 miles, unlike oil, gas, and coal, there is usually only one potential purchaser. So if the local utility is not willing to build a power plant and purchase the power there is no other market. Also, the resource may be in a remote area which will require construction of a power line to get the electricity to a point where it can be utilized.

Accordingly, even with the very best of success and everything working perfectly, it normally takes at least 7 to 10 years to develop a geothermal lease to meet existing requirements of the Geothermal Act. Since 1970, there have been numerous changes in the law in regard to environmental, endangered species and permitting requirements, which have all delayed and lengenthened the time necessary to develop geothermal leases. Therefore, not only is the present 10 year lease period extremely short for development, it is also not long enough from an administrative point of view nor is it sufficient to allow flexibility to ride out economic changes in the market place.

S.1006 eliminates many of the aforementioned problems. It allows a lessee to extend the primary term for successive five-year periods, but not to exceed 15 years, if the lessee has submitted a report to the Secretary detailing a bona fide effort to bring the lease or unit into commercial production given the then current economic conditions. The lessee is also required to drill a well prior to the end of the primary term and prior to the end of each five-year extension or, in the opinion of the Secretary, substantial investments have been made by the lessee during the primary term and each five-year extension.

These provisions will allow a lessee to continue to explore for new fields even though a ready market may not be available. This in turn would place in the Nation's inventory of energy an alternative source ready for utilization when the next energy shortage occurs.

Thank you for the opportunity to appear before your committee.

Senator MELCHER. Thank you very much, Mr. Snow.

Mr. Cherry.

## STATEMENT OF BERNARD H. CHERRY, PRESIDENT, OXBOW GEOTHERMAL CORP.

Mr. CHERRY. Mr. Chairman, I appreciate the opportunity to testify before the subcommittee. My name is Bernard Cherry. I am President of Oxbow Geothermal Corporation.

Oxbow Geothermal is dedicated to the efficient development of geothermal resources in the State of Nevada, and to date they have invested over $70 million in efforts to expand the utilization of Nevada to its thermal potential.

On behalf of Oxbow, I appreciate the opportunity to express support here today for S. 1006, the legislation which has been discussed that would permit the Secretary of the Interior to grant extensions of primary lease terms to qualified geothermal leases.

Oxbow has geothermal interest in five Western states and has Federal leasehold interests in other States for approximately 150,000 acres. Of these leases, about 90,000 acres are located in Nevada.

We are currently in the process of building a 50 megawatt geothermal plant in the Dixie Valley area of Nevada. This project, when it is finished, will cost in excess of $150 million and consist of a 50 megawatt geothermal powerplant and associated 200-mile transmission line for the delivery of electricity to Bishop, CA.

The geothermal steam source for this project will be provided from approximately 60,000 acres of leases which currently constitute the Dixie Valley Geothermal Unit. And the Federal government will receive $1 million to $2 million a year in royalties when production begins.

We have in Dixie Valley invested in exploration and development and resource assessment roughly $15 million to date. And we intend to continue our efforts in this regard.

However, our ability to continue to hold a significant fraction of the leases in Dixie Valley is going to be determined by the availability of additional opportunities to enter to power sales agreements for electricity produced.

And currently, as Mr. Snow indicated, such power sales agreements are not available because of the excess of electricity in the region. S. 1006 is vitally important in assuring that we and the other developers have an opportunity to develop the full potential of all of our lease holdings.

And unless legislation of this type is enacted before the current extension authority expires, we and many other developers stand to lose leases which are valuable and in which we have invested significant amounts of money.

Simply identifying and developing a geothermal resource for use is not sufficient to assure a market, again, because steam cannot be transported over great distances, and powerplants have to be built close to the site.

And geothermal developers have had to assemble the capability to undertake the entire project, from resource discovery to electricity production. I have described the Dixie Valley project as three separate projects, in fact.

The project of drilling and finding resources, the project of building a powerplant, and another project associated with building a very long transmission line. Generally, from the time you begin drilling to find the resource to the time you get that resource into production takes 7 to 10 years.

In our case, the first drilling in the Dixie Valley area was in the late 1970s, and our plant will go into production in April of this coming year.

So about 10 years from the first drilling in Dixie Valley, and of that time almost 2 years was taken up in just permiting various pieces of the project, including the powerplant and the transmission line.

So given these kinds of constraints, we and other developers have been able to commercially develop some leases. Unlike oil and gas, where a shortage of market for the resource may constrain the development, we have in the geothermal business the added development burdens which I have described.

Added to these constraints is the fact that geothermal technology in the industry is still in its relative infancy, and is complicated, and that means that some of the sources of capital that are normally available to other resource forms are not available to the geothermal business.

In sum, we do face some substantially greater barriers to development and utilization than oil and gas and other mineral developers. The industry that exists today is one of large and small energy producers and entrepeneurs who are interested in contributing to our Nation's energy future, while making a fair profit.

It is an industry that in the past few years has experienced considerable change through buyouts and spinoffs, as a result of large oil companies refocusing their priorities and divesting their geothermal holdings and the bankruptcies of many smaller companies that were unable to compete.

Those remaining companies, many of whom are represented here with me today, I believe, are examples of dedicated resource developers who are in legitimate need of additional time to preserve investments for the development of viable electricity production in the future.

We at Oxbow are very enthusiastic about the future of a very important renewable energy resource, one that in most cases is environmentally benign and efficient. Our belief in the business has been demonstrated by the substantial financial commitment which we have made in Nevada.

We intend to continue our efforts in developing geothermal resources in the West. And we urge the subcommittee's favorable consideration of this legislation to assist us and others and in our endeavors. Thank you.

[The prepared statement of Mr. Cherry follows:]

STATEMENT OF

**OXBOW GEOTHERMAL CORPORATION**

presented by

**Bernard H. Cherry, President**

for a hearing on

**S. 1006, The Geothermal Steam Act Amendments of 1987**

before the

**MINERAL RESOURCES DEVELOPMENT AND PRODUCTION SUBCOMMITTEE**

of the

**SENATE ENERGY AND NATURAL RESOURCES COMMITTEE**

on July 14, 1987

Mr. Chairman and Members of the Subcommittee, my name is Bernard H. Cherry. I am President of Oxbow Geothermal Corporation. Oxbow Geothermal is dedicated to the efficient development of geothermal resources in the State of Nevada. To date Oxbow has invested over $70 million in an effort to expand the utilization of Nevada's geothermal potential.

On behalf of Oxbow, I appreciate this opportunity to appear before you today to express support for S. l006, legislation that would permit the Secretary of Interior to grant extensions of the primary lease term to qualifying geothermal leases. We are especially appreciative to Senator Hecht for his strong support and interest in geothermal energy development.

Oxbow has geothermal interests in five western states and has Federal leasehold interests in those states amounting to approximately l50,000 acres. Of these leases, 90,000 acres are located in Nevada. We are currently constructing a 50 megawatt geothermal facility in the Dixie Valley area of Nevada. The project, which will cost in excess of $l50 million when complete, consists of a 50 MW power plant and an associated 200 mile transmission line for delivery of the electricity to Bishop, California. The geothermal steam source will be provided from approximately 60,000 acres of leases which constitute the Dixie Valley Geothermal Unit. Oxbow has invested about $l5 million in exploration and development in Dixie Valley. We intend to continue our efforts in this regard. However, our ability to continue to hold a significant fraction of the geothermal leases in Dixie Valley is going to be determined by the availability of additional opportunities to enter into power sales agreements for electricity produced. Currently, such additional power sales agreements are not available.

S. 1006 is vitally important to assuring that we have an opportunity to develop the full potential of all our leaseholdings. Unless legislation like S. 1006 is enacted before the current temporary extension authority expires (December 31, 1988), Oxbow and many other resource developers stand to lose valuable leases.

Many companies, including Oxbow, have spent millions of dollars in identifying promising geothermal resources. Geological and geophysical studies have been completed, temperature gradient wells drilled, and exploration wells costing up to $3.0 million each have been completed to more accurately identify the resource. However, even after these substantial expenditures, simply identifying and developing the resource for use is not sufficient to assure a market. Because geothermal energy cannot be transported over great distances (the steam energy must be converted to electricity close to its source) we are greatly constrained as to available markets or purchasers. Oxbow, like many other geothermal resource developers, has been required to become a powerplant and transmission developer as well.

Geothermal developers, have therefore assembled the capacbility to undertake entire projects -- from resource discovery to electricity production. We identify and develop the resource, then obtain the necessary permits, pass through the environmental safeguards, negotiate power sales contracts with utilities, acquire transmission rights, and appear before and gain the approval of rate commissions and others before beginning construction on a powerplant project. Generally, from the time a resource developer discovers commercial quantities of a geothermal resource to the completion of a project to utilize the resource, it takes 7-10 years, assuming that all goes smoothly.

Given these developmental constraints, we and other developers have been unable to "commercially develop" some leases. Unlike oil, gas, and coal leases where a shortage of market for the resource may constrain development; geothermal has the added development burdens described above. Add to these formidable constraints the fact that the geothermal technology and industry is still in its infancy compared with oil, gas, and coal. This infancy also means that we lack some of the sources of capital available to traditional fossil fuel development. In sum, geothermal leaseholders face substantially greater barriers to development and utilization than do oil, gas or other mineral developers.

When the Geothermal Steam Act was adopted in 1970, the economic environment and projected demands for energy in the United States were vastly different than they are now. Congress determined a need to encourage the development of safe, environmentally sound alternative energy resources, such as geothermal, in order to foster a domestic energy industry beyond traditional oil and gas that would contribute to our energy security. If the circumstances surrounding the energy crisis had continued, it is unlikely that we would be before you today to request your consideration in extending the leases that we hold, some of which date back to the early 70's.

It is important to note that Congress has granted the temporary extensions only where the leaseholder could show that diligent efforts have been made to develop the lease and a "substantial investment" test was met. Oxbow and others active in geothermal development, are not holding leases for resale. We have spent millions of dollars in identifying resources and, where commercially feasible, intend to develop these resources for the production of electricity.

The test that is provided for in S. 1006 should minimize resource speculation by requiring that a detailed commercial development plan is provided and either drilling has commenced or substantial investment has been made prior to each five-year extension. In addition, the bill contains its own policing mechanisms by requiring the Secretary of Interior to review each lease plan every five years and eliminate those leases he finds not in compliance with the Act.

## CONCLUSION

Since enactment of the Geothermal Steam Act, $80 million in revenues to the Federal government has been raised from leasing of prime geothermal lands such as the Geysers. The government is realizing substantial income from these leases. Approximately $2.5 million per year is raised from lease rentals alone.

Even in the current economic and energy market, there has been significant activity in the development and production of commercial geothermal resources, although admittedly at a slower pace then during the early 1980's.

The geothermal industry that exists today is one of large and small energy producers and entrepreneurs who are interested in contributing to our nation's energy future while making a fair profit. It is an industry that has experienced considerable change through buy-outs, spin-offs, as a result of large oil companies divesting their geothermal holdings, and bankruptcies of smaller companies that were uanble to compete. Those remaining companies, many of whom are represented here today, we believe, are examples of dedicated resource developers in need of additional time to preserve our investments for the development of viable electricity production in the future.

We are very enthusiastic about the future of this important renewable energy resource. Our belief in the future of geothermal has been demonstrated, I believe, by the substantial financial commitment which Oxbow has made toward the development of the Dixie Valley project. We intend to continue our efforts and urge passage of S. 1006 to assist us and others in our endeavors.

Senator **Melcher**. Thank you, Mr. Cherry.

Mr. Falcone.

## STATEMENT OF DOMENIC J. FALCONE, SENIOR VICE PRESIDENT, FINANCE, GEOTHERMAL RESOURCES INTERNATIONAL, INC.

Mr. **Falcone**. Good morning. My name is Domenic J. Falcone. I am Senior Vice President of Finance for Geothermal Resources International, Inc., a fairly small, independent company that is primarily involved in the exploration and development of geothermal resources.

I am a member of the board of directors of the company, as well as the Geothermal Resources Council, and the Geothermal Resources Association.

I will not bother dwelling on the current problems of the industry. I think probably enough has been said and certainly enough is known about the expiration of leases and the lack of current market that we now are facing.

I would point out that we will also be losing some tax incentives sometime by the end of next year. This is an industry that needs to have a sense of the future, and one of the ways you get a feeling of a sense of the future is by being able to feel comfortable about holding onto the assets that you have previously paid for.

And this piece of legislation would certainly help give the industry at least a sense of its future by allowing for leases to be maintained where significant expenditures have been made.

I would like to, since our company has been around since 1966, I probably can highlight a few areas of where we have spent a lot of money on Federal leases, and unfortunately have either lost the leases or will be losing the leases very soon, if this legislation is not passed.

In Long Valley, where one of the first Federal geothermal leases was ever issued under the preference rights through the 1970 act, we had acquired 3,712 acres and had spent $350,000 exploring the acreage.

We also had a partner come in and spend at least another $350,000. And after having spent a total of $700,000 plus in 1985, we were required to give up the leases because of the lack of extension of the geothermal lease bill.

At Dixie Valley, NV, where Oxbow is operating today and will be spending in excess of $100 million, we had 5,760 acres of prospective geothermal properties when we realized that there was no real future for a marketplace over there. We did not spend as much money as we normally would have. But we had to give up those leases not too long ago.

At Steamboat Springs, NV, we had 1,160 acres. We had spent $422,000 at Steamboat Springs demonstrating that there was a geothermal potential there. We have lost that set of leases as well, so $422,000 is also a lost investment to us.

We have other areas where we have spent significant amounts of money in order to determine whether there is a geothermal resource or not. Over the last 6 years, we have actually had expire or gave up 58,500 acres of Federal geothermal lands.

The investment in those lands was in excess of $1 million. And by the end of next year, if this legislation in not passed, the $5 million we have spent at Valles Caldera, NM will also be wiped off the books.

I think it is pretty obvious that a company our size, which is publicly held, cannot afford to have these kinds of assets be wiped out, simply because there is no marketplace and nowhere to go right now with the expenditures and the properties that we have already proven to be of some value from a geothermal point of view.

I think I would like to make a comment. Obviously we are in support of this particular piece of legislation, and to the extent that there is any need for clarifying language, as suggested by the BLM people, we would be more than happy to submit or work with you on getting that language clarified.

There has been a lot of talk this morning about Yellowstone, and I think that all of us agree that Yellowstone is an asset of this country that we have to protect.

I would hope that this legislation will not get bogged down though, because of some protection of Yellowstone that takes a long period of time to work out.

I think that the industry needs to be protected, and I certainly believe that Yellowstone needs to be protected as well, and would hope that somehow or other, if there is going to be anything in the bill dealing with Yellowstone, that we could go ahead and implement that very quickly.

Certainly our company has no desire at all to get involved in exploration or development around Yellowstone Park.

Senator **Melcher**. Thank goodness.

Mr. **Falcone**. With that, as I said before, we support the legislation and would be happy to work with you in trying to get the legislation passed this year. Thank you.

[The prepared statement of Mr. Falcone follows:]

# TESTIMONY OF DOMENIC J. FALCONE
# PRESENTED TO THE SUBCOMMITTEE ON MINERAL RESOURCES DEVELOPMENT AND PRODUCTION OF THE COMMITTEE ON ENERGY AND NATURAL RESOURCES

JULY 14, 1987

Good morning, I am Domenic J. Falcone, Senior Vice President-Finance of Geothermal Resources International, Inc., a moderate sized, independent, geothermal exploration and development company. I am also involved in various capacities on a number of Boards of Directors of various associations which are affiliated with the geothermal industry. I have had the pleasure of appearing before this and other Committees in the past in order to discuss proposed legislation to amend the expiration provisions of the Geothermal Steam Act of 1970.

Our Company has been involved in geothermal exploration and development, principally in The Geysers area of California, since 1966 and was one of the first companies to be granted a federal geothermal lease in California as prescribed by the Geothermal Steam Act of 1970. Later in this testimony I will discuss the fate of those original leases. Since that original act, we, and other companies, through very active exploration programs on federal leaseholds have expanded our geothermal activities into the States of Nevada, Oregon, New Mexico, Utah, and others. Through these efforts we have either proven or disproven the resource value of government owned minerals. As such, we are one of the more active companies in what is becoming a shrinking business activity. This shrinkage is being created by the current electricity generation surplus and significantly reduced oil and gas prices.

After the implementation of the 1970 Act, primarily fueled by the "energy crisis", the geothermal business became a very viable energy industry. A great deal of drilling activity took place because utilities, representing the ultimate market for geothermal steam, had a need to secure a predictable, domestic and clean source of fuel for electricity generation. Additionally, electricity generated by geothermal fuel was competitive with electricity generated by the traditional oil and gas methods and nuclear as well.

If S. 1006 is not passed those of us who have explored and discovered geothermal resources and suddenly had the bottom fall out of that market place would have spent millions of dollars for naught because within a very short period of time our potential market has evaporated. This is one of the many reasons why most leases with private landowners are negotiated in an effort to get a twenty-year lease term.

It is very important to remember that from initial execution of a lease to the first sale of resource, provided everything goes reasonably well, it could take an average of seven years to be in production. That not only means that development, by making large capital expenditures, of the resource must be successful but also that a steam sale contract has to be entered into with an end-user. This type of timing, compared to development of an oil and gas field or coal mine, is not unusual. The major difference comes about in that oil, gas and coal will always have a market whereas geothermal resources due to its site specificity may not. Therefore, sudden turnarounds in the market place require initiating the seven-year process all over again.

The geothermal industry needs time for the next turnaround and cancellation of existing leases, on which considerable evaluation work has been done, would not only be very discouraging but would not be in the best interests of our nation. History has proven that the leasing of federal or even state geothermal rights does not come about in short time frames. It is better to have the leases in the control of those who have spent time and money evaluating these properties than to cancel those leases and delay the development of this excellent alternative resource.

I would like to take just a few minutes to demonstrate the significant negative impact that expiration of federal leases has already had on our Company.

At Mono-Long Valley one of the first federal leases was issued to this Company through the preference right provision of the original Act. The number of acres was 3712 and the Company had spent $350,000 exploring the acreage and another company working with this Company spent at least that much more money and determined that there was a good likelihood that a resource existed at depth. However, the Company was never able to enter into contracts for sale of the resource and in 1985, after a combined expenditure of at least $700,000, the leases were terminated in accordance with their terms and $700,000 of investment became worthless.

At Dixie Valley, Nevada where one of the other companies testifying here today will have invested over $100,000,000 in a geothermal electricity project, our Company had to drop 5760 acres of very good prospective acres because of lack of sale contracts. We did not invest all that much money because we realized that no market would be available to us within the last half of the lease terms.

In 1986, we lost the leases on 1160 acres in Steamboat Springs, Nevada. Our total investment at Steamboat Springs was $422,000. Steamboat Springs is one of the best potential geothermal areas in Nevada and after spending the money to help prove that point further, the Company has lost the value of its investment due to lack of market availability.

In numerous other areas we have spent monies and then dropped the acreage because we knew we would lose the leases in the future due to lack of development caused by a lack of market within the original terms of the leases. Over the last six years, this Company has either dropped or lost through expiration 58,500 acres of potential geothermal lands.

The investment involved has to have approached $1,000,000 and that does not count the $5,000,000 we have invested at Valles Caldera, New Mexico which we will probably lose due to expiration this year and next.

These amounts do not seem like a lot of money to most people but they are significant to my Company and it 3,000 shareholders. This is the reason why we have concentrated our recent leasing efforts on private acreage. At least we have a longer term opportunity to explore and develop the resource and loss or lack of market in the first half of the lease term will not be devastating to our investment.

Finally, it is important to remember that the Treasury receives royalty payments from sales of geothermal resources from these leases and loss of these leases due to expiration and flight to private leases by companies could have a detrimental effect on the federal budgets.

For all of the reasons set forth above, I request this Subcommittee to favorably recommend passage of S. 1006. Thank you.

Senator MELCHER. Thank you.
Mr. Darling.

## STATEMENT OF LES A. DARLING, GOVERNMENT AFFAIRS COORDINATOR, CHEVRON RESOURCES CO.

Mr. DARLING. Mr. Chairman, my name is Les Darling, and I am Government Affairs Coordinator for Chevron Resources Company.

Chevron Resources is a unit of Chevron Corporation, which is responsible for our efforts to diversify into the non-hydrocarbon minerals and geothermal energy businesses. We have mining or geothermal development operations in California, Montana, Nevada, New Mexico, Texas and UT.

We are optimistic about the future of geothermal resource development. We are producing at four geothermal fields in three states, and production is expected to begin from two additional fields in 1987.

We supply geothermal hot water to two power plants. They are the Heber geothermal field, located in the Imperial Valley of southern California. We operate a geothermal field at Roosevelt Hot Springs near Milford, UT, which supports a 20-megawatt plant.

In Nevada we operate the Beowawe Geothermal Power Company, a 16-megawatt geothermal power plant located about 55 miles west of Elko. Also in Nevada, Chevron operates a 9-megawatt geothermal power plant at Desert Peak, about 50 miles east of Reno.

We are currently working with partners in developing small geothermal power plants at Steamboat Springs and Soda Lake near Reno.

Each of our geothermal power generating operations has been developed with Federal geothermal leases included in the production area. We have over 80 Federal geothermal leases covering over 90,000 acres in California, Oregon, Nevada and Utah.

These leases are in various stages of evaluation and development. For a number of technical and economic reasons, however, most are not likely to be producing or utilizing geothermal steam in commercial quantities, as required by the 1970 act during their primary term or the administrative extensions which are scheduled to expire at the end of 1988.

Chevron is facing termination of 11 Federal geothermal leases at five locations in the next 2 years under the terms of the existing law. We have spent over $1 million in evaluating these leases.

In addition, we have 42 leases which will expire in the early 1990s. And our investment in these leases is well over $3.5 million, with a total investment in the geothermal industry upwards of $80 million over the last several years.

We have invested significant time and considerable expense in evaluating these leases. And yet, because we have been unable to construct a powerplant or sell the steam, we face the loss of these leases now.

We think it would be extremely unfortunate, not only for us as lessees, but also for the Federal resource itself, if these leases were cancelled because the 10-year clock runs out at this time.

Lost leases mean a lost resource base, and a loss of all the information that has been developed. For all practical purposes, a new lessee would need to start from scratch.

During the 1970s and early 1980s, those of us in the geothermal industry devoted considerable attention to the development of geothermal resources as one segment of the remedy to the energy shortage prevailing at that time.

As our industry's technical knowledge reached a point where we began installing commercial plants utilizing this energy, the market was suddenly oversupplied and we were faced with a surplus of generating capacity in some areas of the country.

At the same time, the 10-year primary term for many of our industry's Federal leases began expiring. Most experts agree that the energy oversupply and excess electrical generating capacity situation we are now experiencing is temporary.

The energy that we know is possible to produce from geothermal resources will certainly be needed in the future. We feel that the amendments to the 1970 act, as proposed by this bill, provide a reasonable solution to the problem.

As you know, this issue has been facing industry for several years and we have been advocating legislation to resolve the problem for the same period of time. Previous solutions have been complicated by concerns for protection of the geothermal resources associated with our national parks.

We now have the parks protection provisions incorporated in last year's continuing budget resolution, which we feel protects these significant features.

In summary, the geothermal energy industry is just now emerging as a viable contributor to our Nation's energy supply needs. The technology has advanced considerably since the original Federal leasing bill was passed.

It is an environmentally sound industry. It reduces our Nation's need for foreign energy imports. It provides considerable flexibility in adding generating capacity in a relatively short time, if the geothermal reservoir is fully evaluated, and it can be brought into production in relatively small increments to meet energy needs efficiently.

But it cannot do these things if we allow the progress that has been made to be undone by the termination of many leases, because of the temporary market conditions we are facing today.

We urge support for S. 1006. We think it is very reasonable, timely, and prudent public policy. I would like to thank you for this opportunity to offer our statement here today.

We would also like to thank Senator Hecht, his staff, and the cosponsors of this bill for their strong support for the geothermal energy industry. We are convinced that our country will need the energy resources we are attempting to develop.

This legislation will do much to ensure that that resource is available, when it is needed. Thank you, Mr. Chairman.

[The prepared statement of Mr. Darling follows:]

# STATEMENT OF
# CHEVRON RESOURCES COMPANY

A unit of
CHEVRON CORPORATION

on

S. 1006
GEOTHERMAL STEAM ACT AMENDMENTS OF 1987

before the

MINERAL RESOURCES DEVELOPMENT AND PRODUCTION SUBCOMMITTEE

of the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

presented by

Les A. Darling

Chevron Resources Company

July 14, 1987

Mr. Chairman, members of the Subcommittee. My name is Les Darling. I'm Government Affairs Coordinator for Chevron Resources Company. Chevron Resources Company is a unit of Chevron Corporation and is responsible for Chevron's efforts to diversify into the non-hydrocarbon minerals and geothermal energy businesses. We have mining or geothermal development operations in California, Montana, Nevada, New Mexico, Texas and Utah. In addition, we have extensive exploration activities in a number of other states as well as several foreign countries.

Chevron has been and continues to be optimistic about the future of geothermal resources development. We are producing at four geothermal fields in three states and production is expected to begin from two additional fields in 1987. We supply geothermal hot water to two power plants capable of producing over 110 megawatts of electricity at our Heber geothermal field located in the Imperial Valley of Southern California.

Chevron operates a geothermal field at Roosevelt Hot Springs near Milford, Utah. The field, located about 200 miles south of Salt Lake City, feeds hot water to a 20 megawatt electric generating plant owned and operated by Utah Power and Light.

And in Nevada, we operated the Beowawe Geothermal Power Company, a 16-megawatt geothermal power plant located about 55 miles west of Elko, in partnership with Crescent Valley Energy Company, a unit of the Southern California Edison Company.

Also in Nevada is Chevron's 9-megawatt geothermal power plant at Desert Peak, about 50 miles east of Reno. We are currently working with partners in developing small geothermal power plants at Steamboat Springs and Soda Lake near Reno.

Each of our geothermal power generating operations has been developed with federal geothermal leases included in the production area.

We have over 80 federal geothermal leases covering over 90 thousand acres in California, Oregon, Nevada and Utah. These leases are in various stages of evaluation and development. For a number of technical and economic reasons, however, most are not likely to be producing or utilizing geothermal steam in commercial quantities, as required by the Geothermal Steam Act of 1970, during their primary term or during the administrative extensions which are scheduled to expire at the end of 1988.

Chevron is facing termination of eleven federal geothermal leases at five locations in Nevada and Oregon in the next two years under the terms of the existing law. We have spent over one million dollars in evaluating these leases. In addition, we have 42 leases which will expire in the early 1990's. Our investment in these lease areas is over $3.5 million.

The 1970 Act does not allow for the extension of federal geothermal leases if diligent field development has occurred but actual power plant construction, sale of geothermal steam, or other commercial production has been delayed for economic or technical reasons. We have invested significant time and considerable expense in evaluating many of these Federal leases. Yet, because we have not been able to construct a power plant or sell the geothermal steam for largely economic and sometimes technical reasons, we face the loss of the leases. It would be extremely unfortunate, not only for us as lessees but also for the Federal resource itself, if these leases were cancelled because the rather arbitrarily set clock runs out. Lost leases mean a lost resource base and loss of all the information that has been developed. For all practical purposes, a new lessee would need to start over.

During the 1970s and the early 1980s, those of us in the geothermal development business devoted considerable attention to the development of geothermal resources as one segment of the remedy to the energy shortage prevailing at that time. As our industry's technical knowledge reached a point where we began installing commercial plants utilizing geothermal energy, the energy market was suddenly oversupplied and we were faced with a surplus of electrical generating capacity in some areas of the country. At the same time, the 10-year primary term for many of the industry's Federal geothermal leases began expiring.

Most experts agree that the energy oversupply and excess electrical generating capacity situation we are now experiencing is temporary. The energy that we know is possible to produce from geothermal resources will certainly be needed in the future.

The amendments to the 1970 Act, as proposed in S. 1006, provide a reasonable solution to the problem. The bill would allow the Secretary of Interior to issue up to three consecutive five-year extensions to the primary lease term if the lessee performs according to diligence requirements specified by the Secretary.

As you know, this issue has been facing the geothermal industry for several years and we have been advocating legislation to resolve the problem for some time. Previous solutions have been complicated by concerns for protection of geothermal resources associated with our national parks. We now have the parks protection provisions incorporated in last year's continuing budget resolution to ensure protection of the significant thermal features in those parks.

In summary, the geothermal energy industry is just now emerging as a viable contributor to our nation's energy supply needs. The technology has advanced considerably since the original Federal leasing bill was passed. It's an environmentally sound industry. It reduces our nation's need for foreign energy imports. It provides considerable flexibility in adding electrical energy generating capacity in a relatively short time if the geothermal reservoir is fully evaluated. And it can be brought into production in relatively small increments to meet energy needs efficiently.

But, it cannot do these things if we allow the progress that has been made to be undone by the termination of geothermal leases because of temporary market conditions.

We urge your support of S. 1006. It is reasonable, timely and prudent public policy.

Thank you for this opportunity to offer our position on this proposed legislation. We would also like to thank Senator Hecht, his staff and the cosponsors of this bill for their strong support for the geothermal energy industry. We are convinced that our country will need the energy resources we are attempting to develop. This legislation will do much to insure that the resource is available when we need it.

Thank you.

Senator MELCHER. I thank all of you. I do have a few questions.

First of all, Mr. Snow, this project you have at Salt Lake City for 10-megawatts, is that 10-megawatt plant economical? Or is it just there to find out whether you can do it?

Mr. SNOW. Initially, it was a demonstration plant. But we are currently expanding the Salton Sea fields, so it plays a valuable part in demonstrating whether we could handle the severe water that we have encountered in the valley.

Senator MELCHER. In other words, the first 10-megawatt plant probably would not make money, would it?

Mr. SNOW. No, sir.

Senator MELCHER. When you say you are planning to add 210 megawatts of generating capacity, how much of that would be the Salton Sea area?

Mr. SNOW. It would be another 50 megawatts that we have planned for the Salton Sea.

Senator MELCHER. Out of that 210, 50 more would be from the Salton Sea. So you have approximately 1,800 megawatts of generating capacity worldwide.

Would you mind telling us what other countries are involved?

Mr. SNOW. Besides The Geysers, sir, we have been in the Imperial Valley. We have 660 megawatts of generating capacity on line in the Philippines.

This is on the island of Luzon, and this amounts to approximately 25 percent of the installed electrical capacity on Luzon, including the metropolitan area of Manila.

Senator MELCHER. What province is it in?

Mr. SNOW. We have two fields. One is just outside of Manila, and it is 330-megawatts. And then we have another 330-megawatt field on the eastern end of Luzon.

Senator MELCHER. You do not know?

Mr. SNOW. I am not sure which province it is in.

Senator MELCHER. Are you going to develop any more over there in the Philippines?

Mr. SNOW. Not in the Philippines, but we are in the process of developing a field in Indonesia.

Senator MELCHER. In Indonesia?

Mr. SNOW. That is right. In fact, that has been my assignment for the past 5 years, in getting this operation started.

We have completed our exploratory drilling and we are now in the process of entering the development stage for an initial powerplant of 147-megawatts. And this is on the island of Java, just about 50 miles from the capital city of Jakarta.

Senator MELCHER. Mr. Cherry, the Dixie Valley area, you are building a 500-megawatt powerplant now. Is that correct?

Mr. CHERRY. Fifty megawatts.

Senator MELCHER. You are in construction right now?

Mr. CHERRY. Yes, sir. About 20 percent complete right now.

Senator MELCHER. When would that be completed?

Mr. CHERRY. It is scheduled to be completed in the spring of 1988.

Senator MELCHER. Next spring?

Mr. CHERRY. Yes. We broke ground in April of 1987.

Senator **Melcher**. It must be nice to be able to complete a 50 megawatt plant in a year's time.

Mr. **Cherry**. As Mr. Darling said, once the geothermal reservoir is defined and the steam source is defined and you have all the permits, which takes an awful long time—in our case it took 8 years, 9 years—the actual building of the powerplant is relatively straightforward, at least I hope so.

Senator **Melcher**. Mr. Falcone, the leases that you have at Valles Caldera, NM, are they all Federal leases or is there some private and some Federal?

Mr. **Falcone**. I believe they are all Federal leases.

Senator **Melcher**. Well, let us see. Do some of those leases expire this year?

Mr. **Falcone**. They begin to expire this year and continue into next year, as far as exploration is concerned.

Senator **Melcher**. This calendar year?

Mr. **Falcone**. That is correct.

Senator **Melcher**. I thought we extended it into 1988.

Mr. **Falcone**. They were picked up at various times, let us say, in 1977 and 1978. So going forward, they would be expiring in 1987 and 1988.

Senator **Melcher**. Did we not extend in general the geothermal leases into 1988?

Do we read this wrong?

Mr. **Falcone**. OK. As far as—I am not sure all of them qualified for extension under the continuing resolution. That is a year extension.

Senator **Melcher**. Well, let me state at this point, I was in favor of an extension last year and remain in favor of it this year. What we did last year was just sort of a blanket deal. I do not know whether it left some of you out in the cold.

But this bill we have before us now, S. 1006, I believe will be the bill that we pass this year in order to be sure that we have given the opportunity for geothermal development.

Mr. Falcone, you do have quite a bit on private leases, do you not?

Mr. **Falcone**. Oh, yes, we do.

Senator **Melcher**. The bulk of your leases are private?

Mr. **Falcone**. They have become, the bulk of our leases have become private, simply because of the loss of the Federal leases.

Senator **Melcher**. Under what conditions—what are the conditions of those private leases? Are they for a longer period of time?

Mr. **Falcone**. Usually for a 20-year period, which gives you the ability to kind of ride the highs and the lows as your marketplaces may change during that period of time. You get a little more comfort that something will turn around if you spend money up front and then it goes bad. If you have got 20 years, then hopefully things will turn around in that long a period of time.

But we have been gearing ourselves into the private market simply because of the time frames.

Senator **Melcher**. What do they cost?

Mr. **Falcone**. It depends on where the area is, but they are probably not much more than a dollar or two dollars an acre per year, maybe some of them a little higher than that.

Senator **Melcher**. So the period of time is the most significant feature?

Mr. **Falcone**. Absolutely.

Senator **Melcher**. Mr. Darling, in listing the areas where Chevron Resources Company is involved in, you mentioned Texas. Now, in Texas that is not a Federal lease, is it? We do not have any Federal leases there, do we?

Mr. **Darling**. In Texas we have a mineral operation, Mr. Chairman, not a geothermal operation. And it is private.

Senator **Melcher**. It is private. But as I read all this testimony of you four, the bulk of your operations is on Federal land and does involve Federal leases.

Mr. **Cherry**. Absolutely.

Senator **Melcher**. We have a little problem in this bill. It says that we will amend the Geothermal Steam Act of 1970, and first off we would say that we would add a definition "substantial investment."

I think we need some help here. What is a substantial investment? This language that follows does not say what it is. It says it means it is expenditures made. What is a substantial expenditure?

What should that be, if we are going to use that? What should we be looking for? Who wants to volunteer?

Mr. **Falcone**. Could we possibly get back to you on that? It is different.

Senator **Melcher**. You have testified—and I know, Mr. Falcone, you are talking about hundreds of thousands of dollars. You say that might not be a lot of money to some people, but it's a lot of money to your company. Well, it's a lot of money to me, too, but I think this varies.

You have got UNOCAL on the one side that goes all over the world with a proven track record of developing substantial quantities of electrical generation from geothermal, and I do not even want to ask what their budget is for this, Mr. Snow. I do not want to ask.

But what might be substantial to UNOCAL might not fit Oxbow. You might find Mr. Falcone and his company, which is—what is your company—Geothermal Resources International, Incorporated—that is just as long-winded a title. It is even more long-winded than UNOCAL or Chevron.

Mr. **Falcone**. It shows how long we have been around. We captured that back in 1966.

Senator **Melcher**. You suggested that maybe you will submit something. I hope you will, because we need some advice on this.

Mr. **Falcone**. In the past we have had to negotiate essentially with the Bureau of Land Management, for instance, on what kind of a program is reasonable on Federal acreage, and I assume that that is the context that the thing exists in the piece of legislation.

But I think you are probably right, it would be a lot better to have a true benchmark on which you could base your parameter, instead of this, not knowing for sure whether you have reached the benchmark or not.

Senator **Melcher**. Well, later in the bill it says "in the opinion of the Secretary, substantial investment has been made during the primary term." Now, that is supposed to say, if I understand the way we are drafting this bill, that they are going to leave it up to the Secretary; and by using that term "opinion," that that pretty well saves the Secretary from attack because he did not require substantial investment.

But I think if we are going to have a definition of what "substantial investment" is, and I think we should, then I think we need some advice on what that language should be, because I do not think we are seeking anything that would prohibit a new operation, such as Mr. Falcone's company, from getting into something.

Maybe Oxbow is fairly new, too, is it not?

Mr. CHERRY. We are 3 years old.

Senator MELCHER. Talk about $100 million already in your testimony. Congratulations.

Mr. CHERRY. Let me just hasten to add, Senator, that we think long and hard before committing $100,000 to a lease.

Senator MELCHER. I would think so, too. I think what is obvious is that the committee believes that this is an important resource that will be very vital of it is further developed for energy resources of the country.

So knowing that sometimes progress comes from small companies, as opposed to large ones like Chevron or UNOCAL, we do not want to set up something that would be a barrier for small companies to perform successfully to provide energy resources.

So I think we have pretty well established that on private land in general leasing is easier, and that all of you have a mixture of private and Federal. Now, might I ask this general question. Mr. Falcone has already answered it, but I'll ask the other three.

Has this led you to more develop on private land relative to Federal land during the past several years, let us say during the past year?

Mr. SNOW. I will start out on that, sir. The permitting procedures on private land normally are easier. So if you have a choice, equal choice between two locations offsetting, you would most likely drill on the private land rather than the Federal.

Senator MELCHER. Mr. Cherry.

Mr. CHERRY. I agree with Mr. Snow. Given an equal shot at developing resources on a private lease versus a Federal lease, you would tend to go to the private lease because it is easier to move ahead and the time frames on those leases are generally longer.

In our case, almost all of our holdings are Federal leases, almost 99 percent.

Senator MELCHER. You are in Nevada, for one thing, and that is almost all Federal.

Mr. CHERRY. That is right. Almost all of our other leases are Federal leases as well.

Mr. DARLING. That is generally our conclusion as well, and we would much rather develop on a private lease. Unfortunately, we have to develop where the resource is and, as with any other mineral resources, we have to develop it where we find it.

And we are finding it in Nevada, which has a large proportion of public lands, so we are forced pretty much to deal with Federal leases. We do not have the opportunity to choose between Federal and private leases.

Senator **Melcher**. Well, we thank all of you very much. If you can help us with that definition, please give us your suggestions.

Our last witness is Mr. Destry Jarvis, Vice President of Conservation Policy, National Parks and Conservation Association.

We have your testimony, Mr. Jarvis, and it will be made part of the record in its entirety. Please summarize it.

## STATEMENT OF T. DESTRY JARVIS, VICE PRESIDENT FOR CONSERVATION POLICY, NATIONAL PARKS AND CONSERVATION ASSOCIATION

Mr. **Jarvis**. Thank you, Mr. Chairman. I am delighted to summarize it.

I am glad to be back before you again. The last time I spoke before you was in 1979 when you chaired the Forest Subcommittee of Senate Agriculture on this subject. And I must say that, due largely to your leadership, we have made some substantial progress in the problem of the potential threat to park resources of adjacent geothermal drilling. Your leadership, of course, led to the permanent withdrawal of the Island Park known geothermal resource area from leasing for geothermal extraction on Federal lands, and that is to be commended.

The action of the Congress at the end of the last session on the continuing resolution to provide authority and direction to the Secretary for considering significant geothermal features in the parks is also commendable, and we are well along the way to securing some adequate protection for the parks.

However, there are a few remaining problems. In the report submitted by the Secretary to the Congress on June 30th regarding significant thermal features, there are several inadequacies in our opinion.

One is that they have in our opinion misinterpreted the intent of Congress with regard to the definition of significance and the definition or the use of the criteria that Congress outlined.

The result of that misinterpretation is that several parks were left off the list that we believe qualify under the definition of "significant thermal feature." In defining significance, the Department said that a feature must be exceptionally significant for more than one of the criteria when considered collectively.

And unfortunately, further in their definition of the scientific criteria they decided to exclude the consideration of biological factors from the definition of scientific significance. The result of that is that two areas of significance in our opinion were left off the list, one of the springs, one of the hot springs in Big Bend National Park in Texas, and one of the hot springs in Lake Meade National Recreation Area, Nevada, both of which happen to be the habitat of species listed on the Federal list of threatened and endangered species.

We believe that in presenting the Department with the term "significant thermal feature" that Congress did not intend necessarily that it be significantly thermal or necessarily that it only be judged in terms of its geological significance.

We think the Department should be directed by the Congress as an amendment to the pending legislation that biological significance is indeed an applicable criteria, and that these two areas should be added to the list of significant thermal features.

In addition, at Wrangell-St. Elias National Park in Alaska, the Department first found in the draft proposal that the hot springs and mud volcanoes were indeed nationally significant, but in the final concluded not to list them because the area was tentatively conveyed to the native regional corporation in the area.

We believe that the list of significant thermal features is simply a factual determination of significance and should not be influenced by factors such as the potential for disposition of the land.

I would point out that, even with the possibility of conveyance to the native corporation, if it is conveyed this provision would have no effect because it would be private land.

However, the Alaska Lands Act does provide in section 907 a land bank provision for the native corporation, once securing title to the land, to return it for management purposes to the administering agency, in this case the National Parks Service, to be administered to Parks Service standards.

And if that were the case, if the land is indeed conveyed and if it is the choice of the corporation putting it in the land bank, then the National Parks Service should be able to protect it at its standards.

The purpose of the land bank is beneficial to the natives as well, because it exempts them from paying property tax once the land is put under the management and jurisdiction of the federal agency involved.

Finally, the fourth area of inadequacy of the report in our judgment is at Crater Lake National Park in Oregon. Here the single most dominant feature, the reason for its addition to the National Parks System some 50 years ago, was the lake itself, formed in the collapsed caldera of an ancient volcano.

We believe that the Parks Service has substantial and comprehensive enough information to list Crater Lake on the list of significant thermal features and therefore to qualify for the application of the provisions of the Geothermal Steam Act.

In the absence of a decision by the Department to so list, the Department is pursuing a scientific study which they expect to take 4 years. We believe that as long as that study is pending, the Congress should amend S. 1006 to require that no additional leases be granted in the area around the park, and that no new drilling permits be approved on existing leases.

We think these are the minimum necessary steps to adequately protect Crater Lake. We are substantially convinced that they will indeed find hydrothermal vents in the bottom of the lake and that scientific evidence will indicate their importance to the clarity, color, and our knowledge of the lake, which is again the principal reason for its existence as a national park, because Crater Lake is the only park in the system where existing leases occur in the vicinity.

We feel that Congress should also direct the Parks Service to establish a model research program there, one in which they can not only address the problems of monitoring and assessing potential impacts at Crater Lake, but serve as an example for other parks in the system that may in the future come under the application of the Geothermal Steam Act leasing provisions.

Finally, at Yellowstone, Mr. Chairman, I know of keen interest to you, we believe that, while the terms of the Geothermal Steam Act and its leasing provisions are not applicable to drilling on private land, nevertheless this action is of great concern to the future of Yellowstone.

The representative of the churches spoke about the problem of or the insignificance of the fact that the well at LaDuke Hot Springs was some 9 miles, in his estimation, from the nearest feature in Yellowstone National Park. I would say that evidence, and while purely comparative and circumstantial, the evidence in other areas of the world, as you so accurately cited, indicates that when drilling occurs distances are not really a factor as to whether an adjacent area may be impacted.

In New Zealand, when geothermal development occurred hot springs discharges up to 2½ miles away were adversely affected. In Iceland, hydrologic connections were demonstrated within a volcanic caldera that, when a drill hole was punched into the ground, there was instantaneous drawdown 6½ miles away.

In Wyoming's Thermopolis Hot Springs State Park, there was a 20 percent decrease in the hot water discharge coinciding with geothermal drilling 12 miles from the park boundary.

I think, while it is true that we do not know everything there is to know about the geothermal plumbing system at Yellowstone, the inferences that can be drawn from comparable situations are strong enough to be applicable and to require some definitive action.

In the report of the Montana hydrologist cited earlier that did the best and worst case analysis, Mr. Sonderegger, I would note that after his worst and best case analysis he concludes by saying that, because scenic features of a national park are potentially at risk, it would seem prudent to limit geothermal production in some manner.

Now, this is the most optimistic interpretation of the National Park Service's view. I would also say that in a December 15, 1986, letter from the U.S. Geologic Survey to the State of Montana's Water Quality Bureau, the USGS individual indicated that an attempt should be made by the State of Montana to regulate the total amount of thermal water pumped from the underground sources of Yellowstone Valley.

Now, you observed, Mr. Chairman, that State law in Montana perhaps does not allow for that. And I would suggest that in this case we have clearly the most significant thermal feature—well, some might argue that it is not the most, but certainly one that is premier in the world. And we feel there is some Federal responsibility here as well.

We would suggest that, given the inferential evidence that may be drawn, given the work that has been done at Yellowstone, while not conclusive—they have found, for example, through some computer modeling based on the Hydrometrics report that was done at Yellowstone, that they could predict substantial effect at a distance of 9½ miles from LaDuke Hot Springs well after only 30 days of pumping at 400 gallons per minute.

And while there is some question about how much the church intends to pump, and while they have expressed an intent not to pump excessively, we feel that because of the significance of Yellowstone National Park action needs to be taken to give the Park Service the ability to respond immediately to an adverse effect.

Perhaps even beyond that, we would suggest in the extreme that the park boundary be changed and that this area be added to Yellowstone National Park. At a minimum, the Park Service should have the authority under emergency circumstances to condemn the geothermal drilling rights on the private property around the park.

In conclusion, I would simply reiterate that the report of the Department under the previous amendments to the Geothermal Steam Act is not adequate. We believe that four areas should be added to the list of significant thermal features, that is, a spring in each of Big Bend National Park and Lake Mead National Recreation Area, and the Mineral Springs in Wrangell-St. Elias. We believe that evidence is sufficient that Crater Lake could be added to the list, but that at a minimum a moratorium must be imposed statutorily on the granting of new leases or new drilling permits; that a model research program be established at Crater Lake; and that some action be taken at Yellowstone to give the Park Service the ability to move expeditiously in an emergency situation to prevent damage to the premier features of the park.

Finally, I would note that in the Secretary's report to the committee they observe that implementation of the monitoring requirement of the act would require an authorization of $2 million a year for the whole park system to comply with the terms of the Act.

We think that, while that may be an authorized purpose under existing authorities, it would not hurt at all to include an authorization in S. 1006 for this monitoring program, which has been previously authorized.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Jarvis follows:]

STATEMENT OF

T. DESTRY JARVIS, VICE PRESIDENT FOR CONSERVATION POLICY

NATIONAL PARKS AND CONSERVATION ASSOCIATION

before the

SUBCOMMITTEE ON MINERAL RESOURCES DEVELOPMENT AND PRODUCTION

ON S. 1006, GEOTHERMAL STEAM ACT AMENDMENTS

JULY 14, 1987

Mr. Chairman, and Members of the Subcommittee, my name is Destry Jarvis, Vice President for Conservation Policy of the National Parks and Conservation Association (NPCA). NPCA is an independent conservation group dedicated to the protection and preservation of the country's magnificent national parks. On behalf of NPCA's 55,000 members, I appreciate the opportunity to appear before you to present our views on S. 1006, Geothermal Steam Act Amendments of 1987. S. 1006 would encourage geothermal development by extending geothermal leases.

Our primary concern with the legislation pending before you is that the thermal features of the National Park System be adequately protected from any adverse effects of geothermal development. Unfortunately, the history of geothermal development, worldwide and in the United States, has been haphazard, without sufficient safeguards, and has resulted in the irreversable and irreplacable loss of significant thermal features. For example, of the ten major geyser areas in the world, only three have been left undisturbed,

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including Yellowstone National Park. The other seven have either been severely adversely affected, or completely destroyed. The Beowawe Geysers in Nevada (at one time second only to those of Yellowstone in North America) stopped flowing by 1961 after centuries of activity because wells were drilled nearby in the 1940s and 1950s and allowed to discharge. Steamboat Springs, Nevada, has also suffered due to geothermal activities during the 1950s and 1960s.

Congress has shown its concern for these resources by including on last year's Department of the Interior and Related Agencies Appropriations Act for 1987, Public Law 99-591, a requirement that the Department of the Interior evaluate a list of twenty-two National Parks to determine if they contained significant thermal features. The legislation also provided that leasing activities around these parks be suspended until the list had been transmitted to the Congress. The bill contemplates that significant thermal features listed by the Secretary of the Interior pursuant to Public Law 99-591 be carefully monitored. It also provides that any leasing that would be reasonably likely to result in an adverse effect on these significant thermal features not be permitted. The Secretary of the Interior is required to include certain stipulations in geothermal leases that would provide additional protections for the thermal resources.

The report of the Department of the Interior, Significant Thermal Features Within Units of the National Park System, was transmitted to the Congress on June 30, 1987. We appreciate the conscientious approach the National Park Service employed in evaluating potentially significant thermal features within the National Park System. However, there are several areas of the report that are troubling. NPCA does not believe that the report will provide the basis for adequately protecting significant thermal features in several national parks from degradation that could occur as a result of geothermal leasing near their boundaries. Therefore, we are suggesting several changes to S. 1006 that would meet our concerns and allow us to support the bill.

Before discussing our concerns with specific parks, let me explain our basic position with respect to the list of significant thermal features. We view the list as a factual determination of whether or not a thermal feature is significant. Once the feature is determined to be significant based on a simple analysis of the factual merits of the feature, certain protections may, or may not apply. However, the Secretary of the Interior has enormous flexibility in balancing resource protection with development under Public Law 99-591 and the additional authorities granted him under a number of other statutes. The list should be pure--factually based. Whether or not a particular lease may adversely affect a feature is a separate, subsequent determination for which the law provides wide discretion to the Secretary.

For this reason, we urge that a thermal feature be determined to be significant if it is the habitat of an endangered species. The fact that the Secretary has additional authorities and responsibilitites under other statutes, as he does, for example, under the Endangered Species Act, is irrelevant to the issue of whether the feature is significant.

In the proposed list of significant thermal features, published in the Federal Register in February of this year (52 Fed. Reg. 4700), the Department of the Interior proposed to list features in two National Park System units as significant because they were the habitat of endangered species. The Department found Spring No. 1 in Big Bend National Park unique and a significant thermal feature because it is the aquatic habitat for the endangered fish species Gambusia gaigei. Similarly, the Department found a spring in Lake Mead National Recreation Area a significant thermal feature because its waters serve as habitat for an endangered fish species, the Devil's Hole Pupfish. In the final list sent to Congress on June 30th, the Department changed its position. It states, "The Department decided to define "scientific significance" so as to exclude consideration of biological factors because they are considered and protected under the provisions of other laws, such as the National Environmental Policy Act and the Endangered Species Act." Report, P. 7. The original finding of the Department on this issue, that a thermal feature is significant if it is the habitat for an endangered species, is more consistent with Congressional purposes in passing P.L. 99-591. The Congress provided additional park protection measures, including monitoring requirements, in an effort to protect thermal features from the adverse effect of geothermal development. The Endangered Species Act would not necessarily provide the same protections nor would it provide the Secretary the same degree of flexibility in determining a response to a potential threat. For these reasons, NPCA requests that S. 1006 be amended to provide protections from the adverse effects of geothermal leasing for these significant thermal features of Big Bend National Park and Lake Mead National Recreation Area.

Because we view the list as a factual finding, we also object to the Department's rational for changing its determination that the mineral springs (mud volcanoes) at Wrangell-St. Elias National Park and Preserve were significant thermal features. In the proposed list these features met all the criteria for significance. However, in the report, the Department decided not to list them because "New information on the boundaries of the unit reveals that this feature is included within lands designated for interim conveyance to Native Alaskans. Because they are destined to be conveyed outside of the unit's boundaries, the Department removed this thermal feature from the list." (Report, p. 26.) This statement is factually incorrect. Even if Native Alaskans select these lands (which is uncertain), the boundary of the park and preserve do not change. The fact that these lands may be conveyed to the Native Alaskans does not change the fact that they meet all the criteria outlined by the Department in its proposed list and its final list. Furthermore, the Alaska National Interests Lands Conservation Act contains several provisions which might be employed by the Native Alaskans to their benefit and which would allow these areas, if selected, to be managed as park land. Specifically, the Land Bank (Section 907) would provide for management of such lands, at park standards, if the Native Alaskans agree.

We are also concerned that the Department is postponing a decision on whether Crater Lake has significant thermal features. The Department has stated that there will be research conducted at

Crater Lake this summer and a decision about the existence and significance of hydrothermal vents in the lake will be made in the fall. While the Department states that it will not issue any new leases for areas surrounding the park, the report makes no reference to existing leases. There are geothermal drill sites located only one-quarter of a mile from the Park. During the time of the study, and until a decision is forwarded to the Congress, the Department should issue no new geothermal leases or drill permits for existing or additional leases for the areas surrounding Crater Lake.

The scientific evidence found at Crater Lake strongly suggests the existence of hydrothermal vents in the lake and that these vents contribute to the incredible clarity and color and the unique limnology of the lake. It is true that these vents have not been precisely located. We believe this is because the lake has not been sufficiently studied to find these vents. However, national parks were not set aside for speculation and experimentation, nor were they set aside to become the focus of opposing factions of both the scientific and lay communities who have yet to make nondebatable conclusions about what makes Crater Lake's water so spectacular. Any questions should be resolved in favor of protecting the resources.

The National Park Service anticipates a four year study of Crater Lake's water quality. This year's study at Crater Lake is funded at a level of $85,000 and will use towed equipment in an attempt to find where the anomalies suggesting the existence of hydrothermal vents are located. Next year and in 1989, the Park Service anticipates studies at Crater Lake which would utilize a submersible craft which would attempt to pinpoint, and perhaps photograph, the location of the hydrothermal vent or vents. Therefore, NPCA requests that the Subcommittee adopt language to assure that there will be no leasing activities, either by granting new leases or by granting permission for further development of existing leases (i.e., no new drilling permits) until the Park Service has finished its four year study program at Crater Lake. It is unacceptable to NPCA to risk damage to the precious resources of this Park when it is undergoing a thorough study of the cause of its extraordinary water quality.

Further, since Crater Lake National Park has been the focus of so much of the debate about geothermal leasing near units of the National Park System, it should be treated as a model for how the Park Service intends to protect significant thermal features. The Park Service should assure that adequate funding levels permit extensive monitoring of the park resources so that baselines can be established and so that any changes in hydrothermal outputs can be detected, and appropriate management actions taken.

Mr. Chairman, perhaps of most direct interest to you, is the situation at Yellowstone National Park. First, let me commend you again for your leadership several years ago in securing a withdrawal from geothermal leasing of the entire Island Park Known Geothermal Resource Area. Because of its proximity to some of the most prominent geothermal feature of Yellowstone, this area clearly should be, and has been, put off limits to geothermal drilling on federal lands. We appreciate your concern and leadership on this matter. There remains, however, the possibility of geothermal development on private and state lands both in the Island Park area, and on federal and other lands elsewhere around the boundaries of Yellowstone.

Of greatest concern at the moment, is the ongoing geothermal drilling by the Church Universal and Triumphant (CUT) on their property within two miles of Yellowstone's boundary. In addition, as drilling for oil and gas increases around the park, there is the strong potential for such wells hitting geothermal resources, and also for the underground voids which would be left from the removal of oil and gas deposits to serve to draw off thermal fluids or hydrostatic pressure essential to the maintenance of the natural features of the nearby park.

Specifically with regard to the CUT well, our concern centers on the fact that it cuts through the Gardiner Fault, the line of which is directly connected to the contiguous faults interconnecting with the thermal features at Mammoth and Norris Geyser Basins in Yellowstone. The connection of these faults with the CUT drilling site is undisputed. However, it remains unknown whether these thermal areas share a common thermal source, or whether they are independently heated. However, NPCA firmly believes that until and unless it is determined that there is no connection, these areas should remain undisturbed by drilling.

## RECOMMENDATIONS

In conclusion, Mr. Chairman, since the Department's Report is inadequate on several counts, as noted above, NPCA recommends that the pending bill be amended to include specific direction to the NPS as follows:

1. Include on the list of significant thermal features, Spring No. 1 at Big Bend National Park, the Black Canyon Hot Springs in Lake Mead National Recreation Area, and the mineral springs in Wrangell-St. Elias National Park.

2. At Crater Lake, we would strongly urge that the entire park be added to the list now, based on existing information. However, if this is not done, then at a minimum, the bill should include a moratorium on issuance of both new leases, and on approval of new drilling permits for existing leases until ongoing studies are complete.

3. Also at Crater Lake, the bill should require establishment of an adequately funded and staffed research and monitoring capability, since this unit will serve as the model for all future NPS responses to adjacent geothermal drilling activity.

4. At Yellowstone, we urge authorization of a boundary change to bring the CUT property into the park, and appropriation of sufficient funds for its purchase. Absent this, we recommend a special authorization to condemn the geothermal drilling rights of the Church.

Senator **Melcher**. I note that at Crater Lake they're spending maybe $5,000 a year to try to find out where the vents are.

Mr. **Jarvis**. That's the first year of a 4-year study, Mr. Chairman. This year to do some remote sensing activities in the lake.

But next year the price will go up to $250,000. They intend to bring in a submersible craft to definitely locate the vents, and possibly even photograph them.

Senator **Melcher**. And in 2 years they might have something?

Mr. **Jarvis**. The staff of the park believes they know now that that is not good enough, apparently for others. So they feel that perhaps by the fall, they can say yes, there are vents.

Perhaps at the end of 4 years they can say, there are vents. Here they are. Here is the extent, here is the temperature, and here is our conclusion as to how we feel they contribute to the water quality at the lake.

That may or may not occur, depending on the data that they are able to gather.

In any event, because leases exist around Crater Lake, we feel that they will have to have a research program extending well beyond that to monitor the effects in the Park, and to be ready to both ascertain the effects and respond with some kind of a management decision.

Senator **Melcher**. In 2 to 4 years is what you are talking about?

Mr. **Jarvis**. The latter period beyond 4 years, which will have to be ongoing virtually in perpetuity as long as there is leasing activity around the Park.

I mean, we could make a decision, hopefully this fall, certainly I would think based on adequate information, at the end of 4 years, as to whether Crater Lake should be on the list of significant thermal features or not.

Beyond that, it is a monitoring and reaction program, but the decision I would hope could be made this fall, if not certainly at the end of the 4-year research period as to whether the data is sufficient to judge the future significant, as I say.

We think the data is already sufficient for that purpose.

Senator **Melcher**. Passing on to Big Bend National Park and Lake Mead recreation area thermal features, just which endangered species are you talking about that are found in those areas?

Mr. **Jarvis**. In both cases, they are a fish species. At Lake Mead, it's the Devil's Hole pupfish, and at Big Bend, it's a species called gambusia gaigei.

In both cases, they are on the list of threatened and endangered species maintained by the U.S. Fish and Wildlife Service.

I would point out that in our judgment, the list of significant thermal features is a factual determination of significance.

The Congress, we feel, did not intend that that significance only ascribe to its geologic significance but may include its biological significance.

You know very well, Mr. Chairman, that at Yellowstone, many studies have been done of the unique algal forms that exist that produce the myriad colors in the hot springs pools of Yellowstone.

Not that I'm suggesting that those are endangered, but simply to point out that biological significance of thermal features is a factor that should be considered, as well as geologic significance.

Obviously, is drilling nearby affects that feature as drilling for a water well has once done at a place called Acher Meadows in Nevada, affecting this same species of Devil's Hole pupfish——

Senator MELCHER. What kind of fish?

Mr. JARVIS. The Devil's Hole pupfish.

Senator MELCHER. And are you testifying that they need thermal conditions?

Mr. JARVIS. That is right. They exist, they live, their habitat is the hot spring.

Senator MELCHER. And they are on the threatened or endangered species list. But do we find them in other areas?

Mr. JARVIS. The Devil's Hole pupfish exists in several such springs. I am not sure about the gambusia.

The fact that they exist in the Park, in these two units of the National Park System, I think is significant, even though the Park Service, under its organic fact, and the Fish and Wildlife Service and the Park Service under the Endangered Species Act, have a responsibility to protect these species.

What is important here is that the potential protective authorities of the Geothermal Steam Act go well beyond those that exist under the endangered species act.

Under that act, in the absence of a determination of critical habitat under section 7, or in the absence of a carefully worked out recovery plan, the only thing that is required, if a threat is perceived, is consultation.

In this case, Congress we believe intended that if a significantly adverse effect were to occur, there is a definitive requirement on the part of the Secretary to deny the lease and withdraw the area.

That goes well beyond the authorities available, at least in terms of a clear line of decisionmaking, under the endangered species act, that could occur under the endangered species act. But it would not necessarily occur.

We believe the extra layering of authority in this case is appropriate.

Senator MELCHER. I have one more question, and I do not know whether you have thought about it or not, but I will ask you.

Assuming that the natives in Alaska would select the mineral springs at Wrangell-St. Elias, would there be natural protection of the thermal features there? Would it be necessary that something be written into the law to protect those thermal features?

Mr. JARVIS. If the natives select it, and it is conveyed, the title is conveyed, and if they were to choose to develop those thermal features, the provisions of this act nor anything I have suggested would prevent them from doing that.

However, if—and I think the likelihood is high—that they select the land as conveyed, and they choose to put it in the land bank, then the application of this area, the inclusion of this area on the list of significant thermal features, through its administration by the Park Service and the land bank would afford or extend these protections to that.

The boundary of the park does not change if the land is conveyed. These become in-holdings. As you well know, there are many native in-holdings in the parks and other conservation units in Alaska.

And those are intended to be there in perpetuity. And many of them will be managed in this land bank, under the land bank section 907 provisions.

And we think if that happens, we intend nothing here to pressure the natives, one way or another. But if they choose, then this authority ought to be available.

Senator **MELCHER**. Apply this authority if they choose?

Mr. **JARVIS**. Apply it now just as a factual determination of significance. Then the protective authorities would apply if they choose to put the lands in the land bank.

Senator **MELCHER**. All right, thank you very much, Mr. Jarvis, for you testimony. It was very helpful.

Statements by Senator Johnston and Metzenbaum and Hatfield will be made part of the record immediately following the opening statement by Senator Hecht.

I note that Senator Metzenbaum has informed us that there will be some written questions. I would ask that if you receive written questions from myself or any Member of the committee, that you respond within 2 weeks, and we shall keep the hearing record open for 2 weeks.

The hearing is concluded. The subcommittee is adjourned.

[Whereupon, at 1:46 p.m. the hearing adjourned.]

# APPENDIXES

## APPENDIX I

## Responses to Additional Committee Questions

J. BENNETT JOHNSTON, LOUISIANA, CHAIRMAN

DALE BUMPERS, ARKANSAS
WENDELL H. FORD, KENTUCKY
HOWARD M. METZENBAUM, OHIO
JOHN MELCHER, MONTANA
BILL BRADLEY, NEW JERSEY
JEFF BINGAMAN, NEW MEXICO
TIMOTHY E. WIRTH, COLORADO
WYCHE FOWLER, JR., GEORGIA
KENT CONRAD, NORTH DAKOTA

JAMES A. McCLURE, IDAHO
MARK O. HATFIELD, OREGON
LOWELL P. WEICKER, JR., CONNECTICUT
PETE V. DOMENICI, NEW MEXICO
MALCOLM WALLOP, WYOMING
FRANK H. MURKOWSKI, ALASKA
DON NICKLES, OKLAHOMA
CHIC HECHT, NEVADA
DANIEL J. EVANS, WASHINGTON

DARYL H. OWEN, STAFF DIRECTOR
D. MICHAEL HARVEY, CHIEF COUNSEL
FRANK M. CUSHING, STAFF DIRECTOR FOR THE MINORITY
GARY G. ELLSWORTH, CHIEF COUNSEL FOR THE MINORITY

United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510-6150

July 16, 1987

Domenic Falcone
Senior Vice President, Finance
Geothermal Resources International
1825 South Grant Street, Suite 900
San Mateo, California 94402

Dear Mr. Falcone:

Enclosed are additional questions from Members of the Subcommittee on Mineral Resources Development and Production relating to the July 14, 1987 oversight hearing on S. 1006, the "Geothermal Steam Act Amendments of 1987".

The hearing record will be held open through July 28, 1987. Please provide responses to these questions by that date.

Sincerely,

John Melcher

John Melcher
Chairman

JM/lav

Questions from Senator Hecht for Domenic Falcone
for the hearing record on S. 1006

1. Under current law, are there incentives or disincentives to making major expenditures on federal geothermal leases? If so, what are they?

2. About how long, on the average, does it take for a geothermal developer to recover his capital expenditures and begin making a profit?

Geothermal Resources International, Inc.

August 4, 1987

Committee on Energy and Natural Resources
Room 362, Dirksen Senate Office Building
United States Senate
Washington, D.C. 20510

Attention: Ms. Lisa Vehmas

Dear Ms. Vehmas:

I would like to respond to the two additional questions raised by Senator Hecht after the hearing on July 15th.

1. Under current law, are there incentives or disincentives to making major expenditures on federal geothermal leases? If so, what are they?

   Answer - There are currently available to geothermal operators certain federal income tax incentives for drilling not only federal leases but also private leases. The availability of this federal tax incentive is not dictated by location of the drilling activity. However, the current duration of the primary term of a federal lease has become a major disincentive to the drilling or spending of substantial amounts of money on those leases. This is so because there are no markets for geothermal resources (or electricity converted by those resources) at the current time. Without these readily available markets, operators fear that expenditures made on a federal lease could easily be wasted because the lease term will expire without any possibility of an extension before a market develops. This is one of the primary reasons that private leases with up to 20-year lease terms are being negotiated.

1825 South Grant Street, Suite 900, San Mateo, CA 94402 (415) 349-3232

2. About how long, on the average, does it take for a geothermal developer to recover his capital expenditure and begin making a profit?

   Answer - As I have previously testified, from execution of a lease to first sale of resource, provided everything goes reasonably well, an average of seven years would not be unusual before the lease begins production and the geothermal developer begins to recoup his investment.

As to Senator Melcher's question on diligent exploration, I believe that is being answered under separate cover.

If I can be of any further assistance, please do not hesitate to contact me.

Very truly yours,

Domenic J. Falcone
Domenic J. Falcone

J. BENNETT JOHNSTON, LOUISIANA, CHAIRMAN

DALE BUMPERS, ARKANSAS
WENDELL H. FORD, KENTUCKY
HOWARD M. METZENBAUM, OHIO
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GARY G. ELLSWORTH, CHIEF COUNSEL FOR THE MINORITY

United States Senate
COMMITTEE ON
ENERGY AND NATURAL RESOURCES
WASHINGTON, DC 20510-6150

July 16, 1987

Robert Lawton
Assistant Director for Energy and Minerals
Bureau of Land Management
Department of the Interior
18th & C Street, N.W., Room 5647
Washington, D.C. 20240

Dear Mr. Lawton:

Enclosed are additional questions from Members of the Subcommittee on Mineral Resources Development and Production relating to the July 14, 1987 oversight hearing on S. 1006, the "Geothermal Steam Act Amendments of 1987".

The hearing record will be held open through July 28, 1987. Please provide responses to these questions by that date.

Sincerely,

John Melcher

John Melcher
Chairman

JM/lav

## Additional Questions by Senator Melcher
## for the Department of the Interior

1. How many federal geothermal leases are there, and of these, how many are producing in commercial quantities as required under current law? How many will expire if the current law is not changed?
2. How will the Department determine what is a "significant expenditure" under S. 1006?
3. What drilling depths does the Department think represent diligent development of a geothermal lease?
4. The Department transmitted its list of significant thermal features as required by Pub. 99-591 on June 30, 1987.
   - o Why did the Department transmit the list more than two months after the statutory deadline?
   - o What definition of "thermal feature" did the Department use?
   - o On what grounds did the Department decide that the presence of endangered species did not qualify a thermal feature as significant?
   - o What endangered species depend upon thermal features in Big Bend National Park and Lake Mead National Recreation Area for habitat?

  - Please provide information on the basis for the designation of each such species as endangered.
  - When were these species listed as endangered?
  - Where are these species found?
  - Please describe the specific steps that the Department plans to take prior to the issuance of geothermal leases to ensure that development will not adversely effect thermal features within units of the National Park System that are habitat for endangered species.

5. I note that the mineral springs (mud volcanoes) within the Wrangell-St. Elias National Park and Preserve were orginally proposed as a significant thermal feature. However, this was not included because according to the Report, this feature is within lands designated for interim conveyance to Native Alaskans.
   - Please describe the status of this land under the Alaska Native Claims Settlement Act.
   - Is it certain that the land including this feature will be conveyed to Native Alaskans?
   - Why shouldn't this feature be protected pending conveyance?
6. Please explain the review, including the public notification and comment period, that applications will undergo prior to a leasing decision being made.
7. Regarding the geothermal well on the Royal Teton Ranch, does the Department believe that development of the La Duke Hot

Spring could affect thermal resources within Yellowstone Park? What data exists regarding possible connections between the thermal features?

8. What is the level of natural discharge from La Duke Hot Spring?
9. Do you agree that if no more than the naturally ocurring discharge is withdrawn from La Duke Spring, there will be no resulting impact to the aquifer?
10. Please explain the water rights owned by the Royal Teton Ranch as they pertain to LaDuke Hot Spring.
11. How many geothermal leases have been issued in the vicinity of the Crater Lake National Park?
    - o What activities have been undertaken on each lease?
    - o To what depth has drilling occurred on each lease?
    - o Are any applications for approval of additional activity on these leases pending before the BLM? If so, please describe.
12. The Department stated in the Report accompanying the transmittal of the list of significant thermal features that the research necessary to address the question of hydrothermal vents in Crater Lake may take several years to complete. The report then states that the Department will reevaluate the listing and leasing issues of Crater Lake this fall.
    - o When does the Department anticipate making the determination of the significance of Crater Lake?

- Might BLM approve additional activities, such as more drilling, on the already existing leases in the vicinity of Crater Lake prior to that final decision?

13. Section 115(2)(b) of Pub. L. 99-591 requires the Secretary of the Interior to maintain a monitoring program for the listed significant thermal features.
    - What steps has the Department taken to put such a program in place?
    - Please describe the program.

## QUESTIONS BY SENATOR METZENBAUM FOR DEPARTMENT OF THE INTERIOR

1. Pub. L. No. 99-591 requires the Secretary to determine whether exploration, development, or utilization of lands subject to a geothermal lease application is reasonably likely to result in a significant adverse effect on listed significant thermal features.
   - o How is the Department planning on implementing this provision?
   - o What type of information will be necessary to make the determinations?
   - o What action will the Department take when there is insufficient information to determine whether geothermal activity will adversely effect a listed feature?
2. Please describe how the Department plans to implement the monitoring provision of Pub. L. 99-591.
3. What stipulations does the Department anticipate using to protect listed features from adverse effects of geothermal leasing?
4. Please describe the study the Department is planning for Crater Lake.
   - o What are the time frames for the study?
   - o When will the Department make a determination of the significance of Crater Lake?

5. I understand that operations on a lease near Crater Lake were suspended when the well lost circulation.
    - What is the status of the lease?
    - Did the Department ascertain the cause of the loss of circulation?

6. Please explain the Alaska Native selection process as it pertains to Wrangell-St. Elias National Park and Preserve.

SENATOR MARK O. HATFIELD
QUESTIONS FOR THE RECORD
COMMITTEE ON ENERGY & NATURAL RESOURCES
S. 1006, GEOTHERMAL STEAM ACT AMENDMENTS
JULY 14, 1987

With regard to Section 115 of the Department of Interior and Related Agencies Appropriations Act for 1987 (PL 99-591), it is my understanding that the Department of the Interior has concluded that there is insufficient information available to make a determination on a possible thermal feature at Crater Lake National Park in Oregon.

- Is the Department considering further study this summer and fall on Crater Lake to make a determination concerning a thermal feature? If so, when will the Department conclude its study and make a final determination?
- Will geothermal development activities be allowed to continue on the federal lands outside the boundaries of the park while the study is in progresss? If so, please identify those activities. Will new leases be issued while the study continues?
- Can you tell me how many leases have been issued to date on the federal land surrounding the boundary of the park and how many acres of land are involved? Please identify those companies currently holding those leases and how many acres are controlled by those companies. What are the expiration dates of the leases?
- How many geothermal wells or test holes have been drilled on the current leases? What are the dimensions and depths of those wells or test holes? How many drilling permits have been issued to date on those lands? How many applications for drilling permits have been filed?
- Please describe the Department's policies with regard to the monitoring of the developmental activities on the current leases.
- In addition to this summer's study, it is my understanding that the Park Service will embark upon a four year study of Crater Lake. How will that study differ from this summer's study? Are the two studies related? What type of geothermal activities will be allowed while the four year study is in progress? Will any new leases be issued while the four year study is in progress?

- Please explain the Department's intentions with regard to the conclusion of this summer's study of Crater Lake. Will the Department make a conclusive decision this fall, or will it defer the decision until the completion of the four year study? If the decision is deferred, will the policies concerning geothermal development and leasing change or remain the same?

- What studies are being planned to investigate the effects that geothermal development taking place several miles from the park boundaries may have on Crater Lake? In effect, if drilling is being planned on federal land that is seven or eight miles from the park boundaries, will the proposed studies be able to determine the impact that such activites will have on the park itself?

OFFICIAL COMMITTEE FILE
PLEASE RETURN

United States Department of the Interior
BUREAU OF LAND MANAGEMENT
WASHINGTON, D.C. 20240

AUG 10 1987

AUG 7 1987

Honorable J. Bennett Johnston
Chairman, Committee on Energy and
  Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Enclosed please find questions and answers submitted in response to the hearing before the Subcommittee on Mineral Resources Development and Production on July 14, 1987, regarding S. 1006, Geothermal Steam Act Amendments of 1987.

Thank you for the opportunity to provide this material to the Committee.

Sincerely,

Director
Acting

Enclosures

bcc: Honorable Mark Hatfield
     Honorable Howard Metzenbaum
     Honorable John Melcher

[Senator John Melcher]

1. How many Federal geothermal leases are there, and of these, how many are producing in commercial quantities as required under current law? How many will expire if the current law is not changed?

Nationwide, there are approximately 850 geothermal leases. About 25 are producing. About 60 will expire by the end of 1988, if the current law is not amended. In future years, the number of leases coming up for expiration annually will increase considerably.

2. How will the Department determine what is a "significant expenditure" under S. 1006?

We have suggested a technical amendment to the section of S. 1006 that is intended to be a definition of "significant expenditure." Section 2 of the bill should be amended by changing the word "means" to "includes" in the new paragraph (f) to be added to section 2 of the Geothermal Steam Act of 1970. As written, the paragraph does not define "substantial", but merely lists expenditures to be considered, and section 3 of the bill, in proposed section 6(c)(2)(iii), makes it clear that the Secretary of the Interior decides whether the investment is substantial.

This amendment will allow the Department to define the term in a proposed rulemaking, on which public comment will be requested. At this time, we do not know what the proposed rulemaking might contain. However, we believe that it is important that the definition be designed to preserve agency flexibility to allow the meaning of "substantial" to vary in accordance with the particular geothermal prospect and its intended use.

3. What drilling depths does the Department think represent diligent development of a geothermal lease?

This would have to be determined on a case-by-case basis. Ordinarily, the depth would have to be such that there would be a reasonable likelihood of encountering geothermal resources.

ADDITIONAL QUESTIONS BY SENATOR MELCHER

**This question is in eight parts as provided below.**

**Question 4:**

**The Department transmitted its list of significant thermal features as required by Pub. L. 99-591 on June 30, 1987. Why did the Department transmit the list more than two months after the statutory deadline?**

**Answer:**

**The statutory deadline provided 120 days within which to publish the proposed notice in the Federal Register. The Department did so two weeks earlier than the 120 day deadline. The statute allowed only sixty days after publishing the proposed notice in the Federal Register to transmit the final report to the Congress. Included in these sixty days was a thirty day public review and comment period. The public comment period closed on March 16, 1987 and the Department accepted any comments postmarked on that day, which in effect extended the public comment period by yet another week. Therefore, to meet the statutory deadline of 60 days after publication of the proposed notice, the Department had three weeks to evaluate all public comments received, to decide whether the data received during the public comment period was sufficient to revise the proposed list, and to coordinate the findings of the final report among the responsible Interior bureaus. The preparation of and all decisions making up the final report were on "fast track" priority lists within the Department; however, extra time was needed in order to provide a competent and credible product for consideration of the Congress.**

Question 4:

What definition of "thermal feature" did the Department use?

Answer:

The Department used the broadest definition of "thermal feature" so as to encompass surface manifestations of underlying hydrothermal systems and surface manifestations of volcanic processes. This broad definition provided for identified surface features associated with active (or dormant) volcanic or hydrothermal systems to become candidate features for consideration as significant thermal features. Examples of these surface features are warm and hot springs, mud pots, fumaroles, hydrothermal vents, geysers, steaming ground, gas vents, volcanoes, craters, calderas, and rift zones.

Question 4:

On what grounds did the Department decide that the presence of endangered species did not qualify a thermal feature as significant?

Answer:

There is no legislative history on §115 of P.L. 99-591 to assist the Department in applying the four criteria for determining significance, as specified in the Act. Therefore, the criteria were broadly defined and applied to candidate features in the proposed notice. Many respondents commented that application of the criteria in the proposed notice was inconsistently applied because of an overly broad interpretation of the criteria. As a result of public comments received, the Department decided to narrow the application of all the criteria. The second criteria, "scientific and geologic significance," was narrowed so as to exclude consideration of biological factors because they are considered and protected under the provisions of other laws, such as the National Environmental Policy Act and the Endangered Species Act. For those features that were listed predominately because of the presence of endangered species, the geologic orientation of the criteria no longer provided for these features to meet the criteria of the Act, as revised and applied by the Department.

Question 4:

What endangered species depend upon thermal features in Big Bend National Park and Lake Mead National Recreation Area?

Answer:

In Big Bend National Park Spring No. 1 and Spring No. 4 serve as water supply sources for the listed Big Bend Gambusia (Gambusia gaigei). Waters from one of the five hotsprings known as Black Canyon Hotsprings support a refugium for the listed Devils Hole Pupfish (Cyprinodon diabolis) in Lake Mead National Recreation Area.

Question 4:

**Please provide information on the basis for the designation of each such species as endangered.**

Answer:

Gambusia gaigei was listed by the U.S. Fish and Wildlife Service primarily because of an extremely limited total environment in Big Bend National Park. Threats to the species included a declining spring flow that maintained the environment and competition with and predation by the mosquitofish Gambusia affinis. This species is suspected to have the smallest range of any vertebrate in the Nation, and possibly the world.

Cyprinodon diabolis was listed by the U.S. Fish and Wildlife Service primarily because of the unique qualities of this dwarf species and its restricted habitat. The Devils Hole Pupfish has been isolated in Devil's Hole for many thousands of years. Its isolation from other Cyprinodon stocks combined with short generation time, small population size, and unique environment accounts for the distinctiveness of the species.

Question 4:

When were these species listed as endangered?

Answer:

Both of these species have long been recognized as rare and threatened with extinction and therefore endangered. The U.S. Fish and Wildlife Service listed both species under the Endangered Species Protection Act of October 15, 1966, through publication in the Federal Register (Vol. 32, page 4001) on March 11, 1967.

Question 4:

Where are these species found?

Answer:

Cyprinodon diabolis occurs naturally only in Devil's Hole, a deep water-filled limestone cavern located in Ash Meadows, Nye County, Nevada. Gambusia gaigei is found in only one spring outflow near Rio Grande Village in Big Bend National Park, Brewster County, Texas.

[Senator John Melcher]

**4. The Department transmitted its list of significant thermal features as required by Pub. 99-591 on June 30, 1987.**

- **Please describe the specific steps that the Department plans to take prior to the issuance of geothermal leases to ensure that development will not adversely effect thermal features within units of the National Park System that are habitat for endangered species.**

Regulations adopted pursuant to section 7 of the Endangered Species Act of 1973 require formal consultation with the U.S. Fish and Wildlife Service whenever a proposed action (issuance of a geothermal lease or development permit) by a Federal agency (the Bureau of Land Management) may affect a species listed as threatened or endangered, or habitat listed as critical for such species.

Prior to issuance of any geothermal lease or development permit, the Bureau of Land Management (BLM) will assess whether the proposed geothermal development under consideration may affect listed species or critical habitat. Depending on the initial determination of possible effect to the listed species, one of the following sequences of events will happen:

(1) If the BLM determines that the proposed operations may affect a listed species or critical habitat, the BLM must write to the U.S. Fish and Wildlife Service (FWS) stating that the proposed actions may affect listed species or critical habitat, and request the biological opinion of the FWS. BLM must first prepare a "biological assessment" if its proposed action is a "major construction activity." In response, the FWS will render an opinion regarding impact to the species or habitat. The BLM can take no action until consultation with the FWS is complete; or,

(2) If the environmental analysis of the BLM does not show that the proposed operations may affect listed species or critical habitat, formal consultation with the FWS is not required. However, the FWS may, upon reviewing the proposed actions and the environmental assessment, request the BLM to initiate consultation under section 7(a)(2). If BLM agrees to initiate consultation, it can take no action until consultation with the FWS is complete and all findings of the FWS must be addressed by the BLM before a final decision is made on the proposal.

[Senator John Melcher]

5. I note that the mineral springs (mud volcanoes) within the Wrangell-St. Elias National Park and Preserve were originally proposed as a significant thermal feature. However, this was not included because according to the Report, this feature is within lands designated for interim conveyance to Native Alaskans.

a. Please describe the status of this land under the Alaska Native Claims Settlement Act.

The following townships within Wrangell-St. Elias National Park and Preserve have been conveyed to the AHTNA Native Corporation: at the base of and west of Mt. Drum, T. 3 N., R. 1 E, and T. 4 N., R. 2 E.; at the base of and southwest of Mt. Drum, T. 3 N., R. 3 E.; on the flank of Mt. Wrangell, T. 1 S., R. 7 E., Copper River Meridian.

5.b. Is it certain that the land including this feature will be conveyed to Native Alaskans?

Title has vested in the AHTNA Native Corporation for the lands described in a., above. There are no other Native selections at or near the bases of Mt. Drum, Mt. Wrangell, Mt. Blackburn, or Mt. Sanford, the only locales where such features exist within the Park and Preserve, to the knowledge of the Bureau of Land Management.

5.c. Why shouldn't this feature be protected pending conveyance?

According to the Park Service, there are no conveyances pending that include such features. If there are additional structures that are selected by Native corporations, they will be protected. Until such time as the lands are conveyed, they are managed by the National Park Service.

Question 6. Please explain the review, including the public notification and comment period, that applications will undergo prior to a leasing decision being made.

The Bureau of Land Management will conduct a review of geologic and hydrologic information in consultation, as appropriate, with the National Park Service, the Geological Survey, and the Forest Service. This review will result in a description of the likely effects of lease activities. If the proposed leasing is in proximity to a significant thermal feature, the description will be forwarded to the Park Service, which will determine whether the effects are to be considered significantly adverse, adverse, or insignificant. In all cases, an opportunity for public comment will be provided before a decision on leasing is made.

ADDITIONAL QUESTIONS BY SENATOR MELCHER

This question is in two parts as provided below.

Question 7:

Regarding the geothermal well on the Royal Teton Ranch, does the Department believe that development of the La Duke Hot Spring could affect thermal resources within Yellowstone Park?

Answer:

Yes. Based upon available date, the geologic staff of the park believe there is an unacceptable risk to geothermal features in Yellowstone National Park should development occur at the 500 gallons per minute level as originally proposed. The park has embarked on studies to assess this risk.

Question 7:

What data exists regarding possible connections between the thermal features?

Answer:

An article by A.H. Truesdale and B.M. Kennedy, "Yellowstone Before (and After) RARGA (Roving Automated Rare Gas Analyser)", presented during the Rare Gas Conference in 1986, proposed the likelihood of Norris Basin water (in the park) traveling north through geological faults to Mammoth Basin in the park. National Park Service studies of mercury and radon anomalies have provided results consistent with the hypothesis of hot water movement along faults to Bear Creek on the Gardner fault. These studies provide a possible way for Yellowstone waters to move into and along the Gardner Fault on which La Duke Hot Springs is located.

It should be reiterated that data now being collected by the National Park Service will assist in making a risk determination for Yellowstone National Park. A complete subsurface geologic and hydrologic understanding in and around Yellowstone is not available.

[Senator John Melcher]

Question 8. What is the level of natural discharge from La Duke Hot Spring?

We understand natural discharge equals 52 gallons per minute.

Question 9. Do you agree that if no more than the naturally occurring discharge is withdrawn from La Duke Spring, there will be no resulting impact to the aquifer?

There is insufficient scientific information available to provide a comprehensive answer to this question.

10. Please explain the water rights owned by the Royal Teton Ranch as they pertain to La Duke Hot Spring.

It's our understanding that these water rights to La Duke Hot Spring are governed by State water law and are held by private parties who own the ranch. In addition, a junior water right is held by the US Forest Service.

[Senator John Melcher]

11. How many geothermal leases have been issued in the vicinity of the Crater Lake National Park?

A total of 46 leases encompassing 76,500 acres have been issued for the subject lands. All the leases were issued to California Energy Company, Inc., and have an expiration date of December 31, 1993.

11.a. What activities have been undertaken on each lease?

A single plan of operations proposing 15 temperature gradient wells was submitted, of which four have been approved. Two of these have been partially drilled, one to 500 feet and the other to 1,350 feet, with diameters less than five inches at those depths.

11.b. To what depth has drilling occurred on each lease?

One of the wells was drilled to 500 feet and the other to 1,350 feet.

11.c. Are any applications for approval of additional activity on these leases pending before the BLM? If so, please describe.

Not at this time. However, depending on the results of the temperature gradient wells that have been approved, additional operations may be proposed.

[Senator John Melcher]

12. The Department stated in the Report accompanying the transmittal of the list of significant thermal features that the research necessary to address the question of hydrothermal vents in Crater Lake may take several years to complete. The report then states that the Department will reevaluate the listing and leasing issues of Crater Lake this fall.

When does the Department anticipate making the determination of the significance of Crater Lake?

We believe that sufficient information may be available by the fall of 1987.

Question 13:

Section 115(2)(b) of Pub. L. 99-591 requires the Secretary of the Interior to maintain a monitoring program for the listed significant thermal features. What steps has the Department taken to put such a program in place? Please describe the program.

Answer:

The National Park Service has proposed a three part program of studies and monitoring to the Section 115 requirements:

(1) A program for the purpose of establishing a monitoring baseline is planned to include description, study and regularly repeated observational measurements of geothermal features in units of the National Park System (spring description, location, temperature, flow, etc.) and a program to complete geological maps at appropriate scales for all areas with geothermal features;
(2) Geophysical, geochemical, hydrological, and geothermal studies to provide improved subsurface understanding between areas where leasing/preservation conflicts are known to exist; and,
(3) An observation will monitoring program and program of analysis for those areas where geothermal development is proceeding and geology between the developed area and park features is incompletely understood and/or there is potential that the hydrothermal systems may be linked.

[Senator Howard Metzenbaum]

1. Pub. L. No. 99-591 requires the Secretary to determine whether exploration, development, or utilization of lands subject to a geothermal lease application is reasonably likely to result in a significant adverse effect on listed significant thermal features.

a. How is the Department planning on implementing this provision?

The Bureau of Land Management will conduct a review of geologic and hydrologic information in consultation, as appropriate, with the National Park Service, the Geological Survey, and the Forest Service. This review will result in a description of the likely effects of lease activities. If the proposed leasing is in proximity to a significant thermal feature, the description will be forwarded to the Park Service, which will determine whether the effects are to be considered significantly adverse, adverse, or insignificant. In all cases, an opportunity for public comment will be provided before a decision on leasing is made.

1.b. What type of information will be necessary to make the determinations?

Determinations will be made based upon available geologic and hydrologic information, land use plans, and any other information that may be relevant.

1.c. What action will the Department take when there is insufficient information to determine whether geothermal activity will adversely affect a listed feature?

If the Park Service determines that the information base is insufficient, the Park Service will consult with the Geological Survey to confirm whether the information is truly inadequate. If the Geological Survey agrees, leasing decisions will be deferred until adequate information is available.

QUESTIONS BY SENATOR METZENBUAM

Question 2:

Please describe how the Department plans to implement the monitoring provision of Pub. L. 99-591?

Answer:

Monitoring and data collection needs have been identified and a 1989 overtarget funding request has been made. The monitoring program will be planned and developed with BLM, USGS, and other agencies participating under jointly funded studies.

3. What stipulations does the Department anticipate using to protect listed features from adverse effects of geothermal leasing?

The Bureau of Land Management will impose those stipulations specified in section 115 of Pub. L. No. 99-591, the Joint Resolution making continuing appropriations for fiscal year 1987. Additional stipulations may or may not be necessary, and the need for such will be determined on a case-by-case basis.

QUESTIONS BY SENATOR METZENBUAM

**This question is in two parts as provided below.**

Question 4:

**Please describe the study the Department is planning for Crater Lake. What are the time frames for the study?**

Answer:

The program of study proposed for Crater Lake includes three years of field studies and a final fourth year of data analysis and report writing. The purpose of the three years of field study, of which 1987 is the first field season, is to characterize the lake and to more precisely locate hydrothermal signals in the Lake. The effort to characterize the lake bottom and to locate hydrothermal signals was accelerated during the 1987 field season to attempt to assist in the Secretarial decision in the Fall of 1987.

Question 4:

When will the Department make a determination of the significance of Crater Lake?

Answer:

The data collected through the studies planned for Crater Lake will determine the answer to this question. The intention of the Department is to evaluate the data collected this summer and determine whether adequate information exists to decide whether the Report, as transmitted to Congress, should be amended. If data are collected by this Fall that provide for the Report to be amended and to list Crater Lake, the Department will do so this Fall.

[Senator Howard Metzenbaum]

5. I understand that operations on a lease near Crater Lake were suspended when the well lost circulation.

a. What is the status of the lease?

The lease was issued effective January 1, 1984, and is in the third year of its 10-year primary term. California Energy, Inc., has suspended drilling pending completion of an environmental assessment by the Bureau of Land Management to address a revised drilling plan proposed by the company in response to the lost circulation.

5.b. Did the Department ascertain the cause of the loss of circulation?

Loss of circulation in areas of past volcanic activity, where the subsurface is very porous, is not unusual, and in fact is expected from time to time during drilling. The well simply was drilling through one such porous stratum. The well will be cased through this stratum so that drilling can continue. The Bureau of Land Management, in consultation with the National Park Service, the Forest Service, and the Geological Survey, prepared a second environmental assessment on this temperature gradient well to consider specifically whether drilling should continue. Public comments were solicited during this process.

6. Please explain the Alaska Native selection process as it pertains to Wrangell-St. Elias National Park and Preserve.

Section 11 of the Alaska Native Claims Settlement Act of December 18, 1971, identified lands to be withdrawn for selection by both the Native villages and regions. Once these selections are made, the applicants place them in order of priority. The Bureau of Land Management then adjudicates the applications for validity and issues decisions of approval or rejection. When decisions become final, the invalid selections--those that are in conflict with pre-existing patent applications, native allotment applications, military withdrawals, and so forth--are removed from the records and conveyances are issued for valid selections.

QUESTIONS BY SENATOR MARK O. HATFIELD

This question is in two parts as provided below.

Question:

With regard to Section 115 of the Department of the Interior and Related Agencies Appropriations Act for 1987 (PL 99-591), it is my understanding that the Department of the Interior has concluded that there is insufficient information available to make a determination on a possible thermal feature at Crater Lake National Park in Oregon. Is the Department considering further study this summer and fall on Crater Lake to make a determination concerning a thermal feature?

Answer:

Yes.

Question:

If so, when will the Department conclude its study and make a final determination?

Answer:

The study conducted this summer and fall on Crater Lake hopefully will provide sufficient data to settle the question of Crater Lake's thermal character.

[Senator Mark O. Hatfield]

2. Will geothermal development activities be allowed to continue on the Federal lands outside the boundaries of the park while the study is in progress? If so, please identify those activities. Will new leases be issued while the study continues?

No new leases will be issued until such time as a final determination has been made as to whether there is a significant thermal feature within the park and until the House Interior Committee and the Senate Energy and Natural Resources Committee have been notified. Any development activities in existing leaseholds proposed by lessees will be given careful consideration, in consultation with the National Park Service and all interested parties. Authority exists in the leases to prohibit development in the event that the review indicates that unacceptable effects would result.

3. Can you tell me how many leases have been issued to date on the Federal land surrounding the boundary of the park and how many acres of land are involved? Please identify those companies currently holding those leases and how many acres are controlled by those companies. What are the expiration dates of the leases?

A total of 46 leases encompassing 76,500 acres have been issued for the subject lands. All the leases were issued to California Energy Company, Inc., and have an expiration date of December 31, 1993.

4. How many geothermal wells or test holes have been drilled on the current leases? What are the dimensions and depths of those wells or test holes? How many drilling permits have been issued to date on those lands? How many applications for drilling permits have been filed?

A single plan of operations proposing 15 temperature gradient wells was submitted, of which four have been approved. Two of these have been partially drilled, one to 500 feet and the other to 1,350 feet, with diameters less than five inches at those depths.

5. Please describe the Department's policies with regard to the monitoring of the developmental activities on the current leases.

Inspections are made periodically to assure that the lessee/operator complies with permit requirements. The Department is monitoring noise levels of these leaseholds to prevent disturbance of park visitors. We are also specifically monitoring return flows of drilling fluids to detect any unusual or unexpected down-hole conditions.

QUESTIONS BY SENATOR MARK O. HATFIELD

**This question is in four parts as provided below.**

Question:

In addition to this summer's study, it is my understanding that the Park Service will embark upon a four year study of Crater Lake. How will that study differ from this summer's study?

Answer:

The goal of the 1987 field studies is to conduct the initial exploration phase of the originally proposed four year geochemistry and limnology studies. The purpose of the four year study is to locate and characterize the thermal springs at the bottom of Crater Lake. Also these studies will attempt to further characterize the Lake bottom to locate more precisely hydrothermal signals in the Lake. The four year study is planned for completion in 1990 and will be continued regardless of the timing of the Secretary's decision on the significance of Crater Lake National Park for purposes of P.L. 99-591.

Question:

Are the two studies related?

Answer:

Yes. The 1987 study is the first year of three field seasons of planned studies, including the 1987 field season, and one additional year for data analysis and report writing. The effort to chacterize the lake bottom and to locate hydrothermal signals was accelerated during the 1987 field season which may provide the Secretary with sufficient information to make a decision pursuant to P.L. 99-591.

Question:

What type of geothermal activities will be allowed while the four year study is in progress?

Answer:

Geothermal development operations on Federal lands surrounding Crater Lake National Park under leases and permits issued prior to October 30, 1986, were not affected by the enactment of §115 of P.L. 99-591. Thus, such operations will be allowed to continue. Park resources will continue to be protected by the Secretary under other legislation and especially through protective stipulations issued for such leases.

Question:

Will any new leases be issued while the four year study is in progress?

Answer:

If the decision in the Fall warrants amending the Report to Congress, Crater Lake will be listed and any lease applications would be evaluated under the provisions of §115 of P.L. 99-591. The determinations made under these provisions would determine whether such leases would be issued with stipulations or whether the lands under application would be withdrawn from further leasing consideration. No geothermal leases will be issued for lands surrounding Crater Lake National Park until such time as a determination has been made and forwarded to the Committees. If the decision in the Fall is to continue not to list Crater Lake because data indicates that the thermal character of Crater Lake is not significant, leases may be issued under the Geothermal Steam Act.

QUESTIONS BY SENATOR MARK O. HATFIELD

**This question is in two parts as provided below.**

Question:

Please explain the Department's intentions with regard to the conclusion of this summer's study of Crater Lake. Will the Department make a conclusive decision this fall, or will it defer the decision until the completion of the four year study?

Answer:

The intention of the Department is to evaluate the data collected this summer and determine whether adequate information exists to determine whether the Report, as transmitted to Congress, should be amended or reaffirmed. If data is collected by this Fall that provides sufficient information for the Report to be amended, the Department will do so; thereby, removing the necessity of waiting for the conclusion of the four year study.
The data that will be collected this summer and analyzed this fall will determine the answer to this question.

Question:

If the decision is deferred, will the policies concerning geothermal development and leasing change or remain the same?

Answer:

If the decision is deferred, the policies of the Department will not change in regard to its willingness to protect Crater Lake from adverse effects. The decision on June 30 is evidence of the Department's willingness to exercise its authority under Section 3 of the Geothermal Steam Act to protect Crater Lake National Park and the Department will continue to do so.

## QUESTIONS OF MARK O. HATFIELD

**This question is in two parts as provided below.**

**Question:**

**What studies are being planned to investigate the effects that geothermal development taking place several miles from the park boundaries may have on Crater Lake?**

Answer:

The National Park Service has proposed comprehensive geological, hydrological, and geophysical studies for Crater Lake to augment monitoring which include the following:

(1) the geochemistry and limnology of Crater Lake;
(2) detailed geological and hydrological studies of the areas proposed for development;
(3) geophysical studies of the subsurface from the park to the area of development, including gravity, magnetics, and electrical techniques; and,
(4) reservoir monitoring and reservoir studies of the development area including hydrothermal alteration and reservoir modelling of the hydrothermal system.

Question:

In effect, if drilling is being planned on federal land that is seven or eight miles from the park boundaries, will the proposed studies be able to determine the impact that such activities will have on the park itself?

Answer:

Yes. The studies and monitoring discussed in the previous question would include proposed lease sites seven to eight miles from the boundary and would provide data to assess impacts of each development proposal.

# APPENDIX II

## Additional Material Submitted for the Record

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VAN NESS, FELDMAN, SUTCLIFFE & CURTIS
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*NOT ADMITTED IN DISTRICT OF COLUMBIA

July 28, 1987

The Honorable John Melcher
Chairman, Mineral Resources Development
and Production Subcommittee
Senate Committee on Energy & Natural Resources
362 Dirksen Senate Office Building
Washington, D. C. 20510

Dear Senator Melcher:

On July 14, 1987, some member companies of the Geothermal Resources Association, including Unocal, Chevron, Oxbow Geothermal and Geothermal Resources International, testified before your subcommittee on S. 1006, a bill to amend the Geothermal Steam Act of 1970. At that time you requested that the geothermal industry provide you with a more detailed definition of "substantial investment" as it pertains to the application for a lease extension.

With respect to your request, the industry is concerned that it would be very difficult to establish a specific financial threshold that would be fair and equitable to all leaseholders and still satisfy the concerns of Congress and the Department of Interior. The geothermal industry is now comprised of companies of varying nature, size and financial circumstances. A specific dollar amount would not account for the varying size and financial strengths of companies currently involved in geothermal development. Further, a set dollar amount would also take away much of the Secretarial discretion that exists in the current definition of "substantial investment".

As currently drafted S. 1006 provides a definition of "substantial investment" which we believe establishes the necessary statutory language to direct the Secretary of Interior to make an informed judgment about the commitment of a leaseholder to the development of a lease. The language clearly directs the Secretary to determine whether one or more of the following expenditures have occurred prior to granting a five-year lease extension:

> "drilling exploratory, developmental, or temperature gradient wells; geological, geochemical, or geophysical surveys; environmental studies; architectural and engineering services procured in connection with design of generating facilities; or other expenditures approved by the Secretary."

I am informed by geothermal company representatives that the costs associated with the activities listed in the bill that must take place prior to approval of a lease extension could range from $100,000 to $3 million. We believe that for any company, small or large, those costs are "substantial" and demonstrate a commitment on the part of the company to develop the lease. For each additional five-year extension (with a maximum of three extensions permitted), the leaseholder must demonstrate further expenditures.

In addition to the costs usually associated with developing a specific lease, many companies must also make significant expenditures to ensure that the geothermal energy is converted to useful thermal energy or electricity. This means that the resource developer must also make expenditures to use the resource once developed. Expenditures for power sales contracts, powerplant development, and other associated activities -- all for the benefit of the geothermal resources from a particular lease or set of leases--should also constitute part of a substantial investment test. By giving the Secretary discretion we believe that all of these expenditures can be considered when a determination of significant investment is made.

Over the six-year period that the Congress has deliberated the lease extension issue, the industry has been under increasing economic pressures resulting from a depressed energy market generally, uncertainty in the tax laws, and a temporary "power glut" in the western states. Despite these very discouraging circumstances, a significant number of companies remain committed to developing and producing geothermal resources. In order to continue as viable energy companies, it is vital that these leaseholders be able to hold the proven leases and then be in a position to develop them when the current circumstances change.

Your interest and leadership in the matter of geothermal lease extensions is very much appreciated. On behalf of the members of the Geothermal Resources Association, we would be pleased to provide whatever additional information you or your staff may require.

Sincerely,

Ben Yamagata

Ben Yamagata
Attorney for the GRA

Geothermal Resources International, Inc.

August 5, 1987

BY OVERNIGHT COURIER

The Honorable John Melcher
Chairman, Mineral Resources Development
and Production Subcommittee
Senate Committee on Energy & Natural Resources
382 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Melcher:

Reference is made to S. 1006 entitled "Geothermal Steam Act Amendments of 1987" and your request to receive a more specific definition of "substantial investment" from the geothermal industry; this being one of the criteria utilized in establishing a determination for lease extensions.

Current regulations (43 CFR §3203.5) provide for the lessee to expend, on exploration operations, a minimum of $40.00 on each acre of leased land during the term of the lease - a substantial investment in and of itself. Consider a block of four leases covering approximately 10,000 acres - this would amount to an expenditure of $400,000, not a small amount by any standard. Additionally, the existing regulations also provide for a minimum expenditure of $12/acre per year for a lease in its 10th to 15th year - or a total of $60/acre for this five year period. A similar dollar amount could be applied to the extended periods of time as proposed in the S. 1006.

As currently drafted, the definition of substantial investment includes a variety of technical operations employed by the geothermal industry to assess the existence and capability of an area's resource. The incorporation of fixed dollar amounts into this definition would not serve to accurately or equitably create criteria embodying the intent of a "substantial investment." The amount or degree of costs associated with all exploration operations are directly impacted by certain site-specific factors. These include depth to potential resource, type of geological formations encountered, and even surface geography. For example, the cost of drilling a geothermal well to the total depth of production in The Geysers in northern California (some to 10,000 feet in depth) ranges between 2 and

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2 1/2 million dollars. However, in Imperial County, California, the depth to production can be only 4,500 feet with resulting costs of $700,000 to $900,000. Thus, the investment necessary to establish a potential resource varies and is largely dependent on the particular site chosen for such operations. This analogy is applicable to all types of exploration and development operations throughout the Western United States. It would be reasonable to conclude that in both of the cases described above, a "substantial investment" was made, though the monetary expenditures widely differed. Yet, with a fixed dollar amount as a basis for such determination, an operator with less expensive exploration costs could be denied a lease extension regardless of the specific operations performed or resulting data.

We believe that discretionary judgment, on a case by case basis, is absolutely necessary in order to insure an accurate and equitable determination of the factors surrounding each extension request. For the reasons previously described in our company's written and oral testimony, we strongly urge passage of S. 1006 as drafted.

Very truly yours,

Peter A Hanse

Peter A. Hansen
Vice President - Land and
Environmental

PAH:LMD:lg

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# STATEMENT

of

Joseph G. LaFleur,
Geologist,

CALIFORNIA ENERGY COMPANY, INC.

Before the Subcommittee on Mineral Resources Development and Production

U.S. Senate

Committee on Senate Energy and National Resources

in support of S1006

Amendment to the Geothermal Steam Act of 1970

July 14, 1987

The following Article, originally prepared for submittal to Transactions of the Geothermal Resources Council, is here provided to supplement the record of the hearing of July 14, 1987 before this Committee. It is intended as a response to the testimony of Destry Jarvis of the National Park and Conservation Association, wherein it was suggested that S.1006 address, in some manner, geothermal development near Crater Lake. For reasons expressed in the Article, the suggestion is inappropriate.

S.1006 is important legislation for its stated purpose: to provide extensions for leases held by geothermal developers who meet the qualifications thereof. To address extraneous matters would not be productive; to address supposed problems based on flawed premises would be seriously counterproductive.

Respectfully submitted,

Joseph G. La Fleur

Joseph G. La Fleur
Santa Rosa, California

# LEGEND OF THE CRATER LAKE HOT SPRINGS
## A PRODUCT OF MODEL MANIA

JOSEPH G. LA FLEUR

CALIFORNIA ENERGY COMPANY
SANTA ROSA, CALIFORNIA

## ABSTRACT

Lines of indirect evidence and, primarily, conclusions from hypothetical modeling have led some researchers to theorize that hot springs may occur on the bottom of Crater Lake, Oregon. It was the stated opinion of some National Park Service representatives that thermal vents actually exist and somehow contribute to the quality of the lake water. The Department of Interior is currently evaluating the topic. Although hot spring discharge would be deleterious to the clarity of the lake, the reported loss of clarity is more likely attributable to sewage contamination. The actual presence or absence of hot spring vents has become a serious point of consideration due to expressed concern that the hypothetical hot springs might theoretically be affected by possible geothermal development outside of the National Park. Although direct hydraulic communication between the lake and any possible commercial hydrothermal system on the flanks of Mount Mazama is highly unlikely due to the geohydrologic setting, expressed environmental concern has resulted in a temporary moratorium on the issuance of federal geothermal leases. This issue illuminates a growing problem within the geosciences; that the overextension of data through modeling procedures promotes inaccuracies and misunderstanding. This paper examines the hypothetical modeling and interpretations of Crater Lake data and addresses the validity of the resultant conclusions. Objective review of the applied modeling procedures and lines of evidence illustrates that there is no reliable evidence for the presence of thermal vents but there are impressive lines of negative evidence that argue strongly against the existence of the legendary Crater Lake Hot Springs.

## INTRODUCTION

Crater Lake, Oregon partially fills the collapse caldera formed during the climactic eruption of Mount Mazama about 6,850 years ago (Bacon, 1983). The steep-sided caldera walls rise from 600 feet to almost 2,000 feet above current lake surface level which is at an elevation of 6,176 feet. Mass-wasting of the poorly vegetated caldera walls is commonplace. The lake is circular with a diameter of approximately 5 miles and an estimated volume of 4.56 trillion gallons (Phillips and Van Denburgh, 1968). Although Crater Lake is the deepest lake in the United States (maximum recorded depth 1932', mean depth 1066' (Simpson, 1970)) it is most accurately envisioned as a shallow plate of rain water held up to the sun and buffeted by strong winds. The lake water is quite pure containing about 80 ppm total dissolved solids (Phillips and Van Denburgh, 1968).

Exceptional optical clarity, facilitated by low nutrient levels is responsible for the lovely deep blue color observed from the rim (Smith, et al., 1973). The lake bottom temperatures are ubiquitously less than 4 °C (Williams and Von Herzen, 1983).

Over the last five years or so, various hypothetical models have been applied to some observed aspects of the lake. The impression, currently held by some of the National Park Service personnel, that significant thermal springs discharge on the bottom of the lake, stems from the conclusions of these hypothetical models. These hypothesized conclusions include: 1) Hydrothermal convection in the caldera floor to depths of 1.5 to 2.0 km (Williams and Von Herzen, 1983); 2) Thermal spring discharge rates of 30-150 L/sec (Sorey, 1985); 3) Thermal spring discharge temperatures of 23° - 200°C (Nathenson, PMT*, 1987); 4) Hydrothermal transport of helium and radon into the lake (Dymond, 1986); 5) Enrichment of common metallic cations on the lake floor by hydrothermal venting (Collier & Dymond, PMT, 1987).

If one is to objectively evaluate the validity of these conclusions it is necessary to first objectively evaluate the assumptions upon which the models were built. To date these models have been based on two principal assumptions: 1) That Crater Lake is analogous to an oceanic spreading center and; 2) That the chloride content of Crater Lake (about 10 ppm) is in theoretical steady state balance maintained by hypothetical thermal water discharge. Since there is no logical or factual support for either of these basic model assumptions, an objective scientist would have to view the conclusions as speculative at best. In instances where these conclusions result in what is seemingly physically impossible, they should be viewed with healthy skepticism. This paper examines the suggested lines of evidence for thermal venting and draws conclusions regarding alternative explanations. It is written to interest both scientific and non-scientific readers and is structured chronologically to illustrate how a legend grew into a problem.

*Note: PMT in a citation stands for Portland Meeting Tapes. These are transcript tapes of the February 24 & 25, 1987 GRC-sponsored Crater Lake Meeting held in Portland, Oregon.

LA FLEUR, JOSEPH G.

## BIRTH OF THE LEGEND

The Legend of the Crater Lake hot springs began in 1983 when David Williams, USGS Denver, and Richard Von Herzen, Woods Hole, published an article in J.G.R. claiming that "two thermal spring areas were discovered on the deep lake floor" (Williams & Von Herzen, 1983). This discovery claim was based on the modeled interpretation of two types of temperature data recordings. One data set was temperature gradients measured in the top 0.5 to 2.5 meters of the lake floor sediments (ibid., p. 1096). The other data set was vertical temperature profiles of the deep lake waters. The temperature gradient data showed two areas of elevated heat flow in the sediments (Fig. 1). Based on their experience with oceanic spreading centers, Williams and Von Herzen concluded that these areas of higher heat flow indicated convection of lake water within fault/fracture permeability. I have no disagreement with that concept but it is not a unique interpretation applicable to the data. The areas of elevated heat flow could just as easily reflect conductive heat transfer from a slower-cooling igneous rock in the lake subfloor. Also, a heat flow anomaly, be it from an underlying convection cell or from a near-surface cooling rock body, is not evidence of thermal spring discharge. High heat flow values are commonly recorded in areas where there are no hydrothermal vents.

Having theorized that convection cells produced the observed heat flow anomalies, Williams and Von Herzen turned to numerical modeling of oceanic spreading centers to calculate the depth of convection. The distance between the two heat flow anomalies was defined as a "wavelength" and concepts of convection within a homogeneously permeable medium were applied to conclude that the convection "cells" are equidimensional (Williams & Von Herzen, 1983, p. 1098). The modeling concepts applied came from Hartline & Lister, 1981, wherein they addressed the theoretical spacing of convection cells in uniformly permeable fault zones in oceanic crust. Application of this oceanic model to the Crater Lake heat flow anomalies assumes a hypothetical through-going NNE trending fault zone connecting the two thermal areas. The authors theorized that the southern anomaly was due to venting along a "north facing scarp" (ibid., p. 1098). The model applied does not fit the heterogeneity of a caldera floor nor the field observations of the authors nor the observations of Bacon that "No regional faults have been recognized in the walls of Crater Lake Caldera" (Bacon, 1963, p. 61). The conclusions of the modeling should therefore be viewed as speculation.

Williams and Von Herzen applied still more mathematical modeling to further describe the hypothesized convection cells and a theoretical horizontal hydrothermal aquifer connecting them.

> "Our heat flow data fit the theoretical curves best for fracture heights between 1 and 2 km and for fluids entering the

From: WILLIAMS AND VON HERZEN: CRATER LAKE HEAT FLOW, 1983

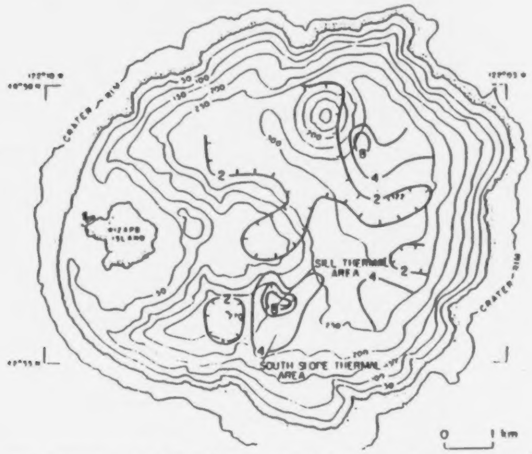


Fig. 1, Heat flow contours at a 2 HFU (84 mW/m²) contour interval. Contours above 8 HFU (334 mW/m²) are omitted for clarity.

> fissure at temperatures between 100° and 200 °C. This height would be the depth to the top of a hydrothermal aquifer. In these calculations we assumed a thermal conductivity for the sub-lake floor rocks of 1.26 W/m K (3 x $10^{-3}$ cal/cm s °C), a background heat flow of 125 mW/$m^2$ (3HFU), and a ratio of entering to exiting temperatures of 0.5.
>
> If we assume the aquifer that supplies fluids to the thermal area causes the 3- to 4-km variations in the heat flow fields, then we can roughly describe this aquifer. Its top lies at a depth of 1 to 2 km beneath the lake floor. It is 1° to 2 km thick and has a temperature between 100° and 200°C" (Williams & Von Herzen, 1983, p. 1098).

If translated literally, this modeling requires the thermal fluid to enter a vertical fracture at 100 ° to 200 °C, double in temperature while ascending, exit at 200° to 400°C, and then, to lie flat on the bottom of a 4 °C lake. "Dense thermal waters pond in the southwest basin" (ibid., p. 1094). Although this type of thermal modeling is obviously hypothetical, it was considered "far stronger than mere speculation" because it was "published in a definitive paper in a prestigious peer-reviewed scientific journal" (Muffler, 1986a). This statement by Muffler has been quoted by the local Park Service personnel to support the hot spring contention (Medford Mail Tribune, 1987). Even if the peer reviewers had recognized that the authors transposed "exiting" and "entering," the model would still require 50 ° to 100 °C to lie flat on the lake bottom. Also, if the "thermal fluid" is more dense than the lake water, why would it be ascending in the first place?

The concept that thermal spring discharge is actually occurring came largely from the interpretation of deep water temperature profile data (Williams and Von Herzen, 1983, p. 1098). These data showed one area where bottom water temperatures increased slightly (about 0.1 °C) with depth approaching the lake floor (bottom 285 meters) (ibid., p. 1100). These data were plotted on a greatly exaggerated vertical scale as shown in Fig. 2. This data plot was described as "convincing evidence that dense thermal waters are ponding in the southwest basin" (ibid., p. 1101).

Williams and Von Herzen described the deep water temperature profiles as a "thermal plume" despite the fact that the anomaly lies flat on the bottom of a less than 4 °C lake. One might consider that whatever was making the hypothetical thermal water "dense" would soon plug the hypothetical vent. The authors provided the following complicated explanation of how this phenomenon was supposed to work:

From: Williams & Von Herzen, 1983

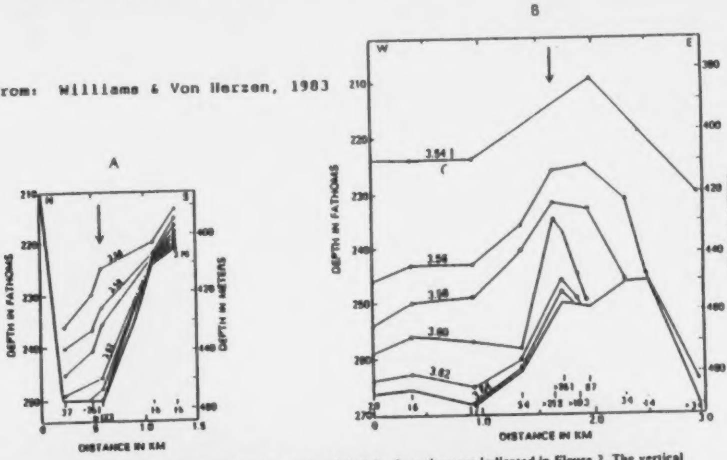


Fig. 2 . Cross sections of isotherms in the deep water of the lake. Locations are indicated in Figure 2. The vertical arrows indicate where the two profiles cross. Dots are actual data points. The numbers on the isotherms are the temperature in degrees Celsius. The lower heavy dark lines are generalized bathymetric profiles. The numbers below the line are the conductive heat flow values measured along the profiles. (*a*) A north-south profile through the water above south slope thermal area and the sill-thermal area. (*b*) A nearly east-west profile through the water above sill-thermal area. Not all the data are shown above the thermal areas. The data in the region were complicated with common small (0.01°C) temperature reversals. We were not able to unravel the data in detail because the station spacing was less than the accuracy of our positioning and there may have been temporal variation in temperatures during the 10-day period in which the data were gathered.

> "The thermal fluids that discharge from the springs behave in a complex manner. Some of the fluid rises in a plume and rapidly mixes the deep lake waters. The rest of the fluid is dense and flows down slope where some of it mixes turbulently with the overlying lake water and the rest ponds on the lake floor where the mixing process is considerably slower. The Red Sea brines area is a good example of this process at its extreme" (ibid., p. 1102).

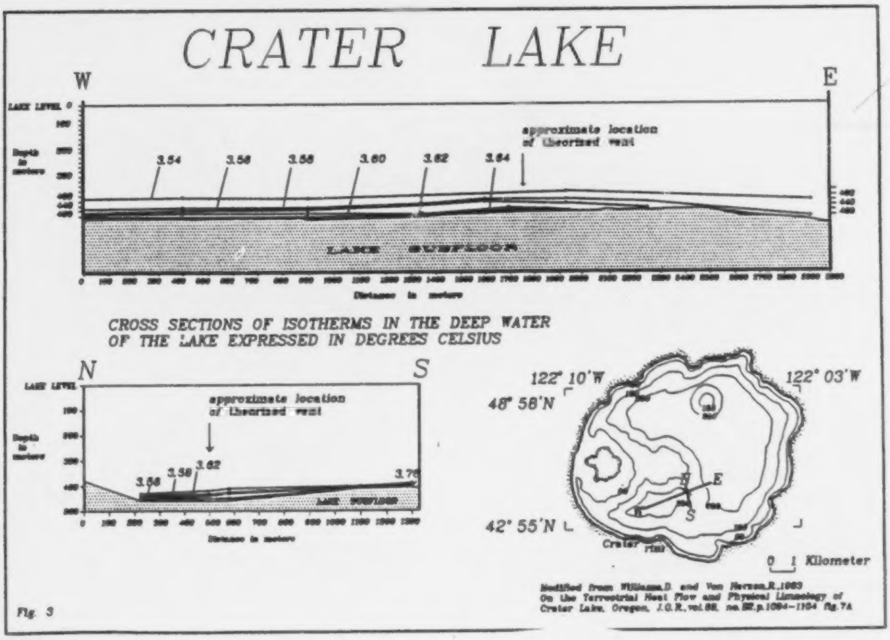
A replotting of the deep water temperature profile data on a non-exaggerated scale affords a realistic perspective (Fig. 3). These plots illustrate a fairly uniformly layered vertical section of isotherms that quasi-uniformly increase in temperature approaching the lake bottom. The reader is encouraged to compare these undistorted plots with the hypothesized "plume" description quoted above. Note that the authors' complicated interpretation demands the following: 1) That the hypothetical thermal fluid moves laterally away from the suspected source a distance of 1.7 km without any temperature loss (seemingly a physical impossibility); 2) That the thermal fluid remains uniformly thermally stratified over that distance with the warmest layer on bottom and; 3) That the thermal fluid flow runs uphill in one direction and downhill in the other while still lying flat on the bottom of the lake.

A much simpler and perhaps more logical interpretation of the deep water thermal anomaly is that it is produced by conductive heat transfer. Interpretation as a conductively heated layer would explain why it is warmest on bottom and displays lateral uniformity. In light of this simpler and seemingly more plausible alternative explanation, the deep water temperature profiles are not reliable evidence for thermal fluid venting.

## THE LEGEND GROWS

One of the inherent pitfalls of model mania is that subsequent authors often build upon previous author's conclusions without adequate scrutiny of the original hypothesis. Once the Williams and Von Herzen hypothesis of thermal venting was published, other researchers soon began attributing all of the chemical idiosyncrasies of Crater Lake solely to currently active hot springs. Other plausible hypotheses were excluded in the rush to contribute to the new "discovery" despite the subjectivity of the interpretation of the less than 0.1 ° C observed temperature variation.

At the 1985 annual meeting of the AGU, three USGS scientists presented a poster with abstract



CROSS SECTIONS OF ISOTHERMS IN THE DEEP WATER OF THE LAKE EXPRESSED IN DEGREES CELSIUS

Modified from Williams,D. and Von Herzen,R.,1983 On the Terrestrial Heat Flow and Physical Limnology of Crater Lake, Oregon, J.G.R.,vol.88, no.B2,p.1094-1104 fig.7A

Fig. 3

entitled "Evidence for Thermal Water in Crater Lake, Oregon" (White, et al., 1985). The concentrations of Na, Cl, $SO_4$, Li and B in Crater Lake were decreed to be anomalously high in comparison to the cold springs on the flanks of Mount Mazama (ibid.). This is akin to comparison of an apple to an orange and declaration that the pips are anomalous. Snow melt coursing down through fractures and lava flow boundaries to rapidly exit as springs on the flanks, would have little in common (aside from meteoric origin) with ponded lake water subject to an entirely different geochemical environment. White et al., (1985) hypothesized that thermal water discharges into Crater Lake because "Crater Lake water contains significant quantities of many chemical species (e.g. Cl, $SO_4$, Li and B) commonly found in hot spring waters associated with volcanoes . . ." The actual concentrations of these chemical species in Crater Lake were given as: Cl 9.6 mg/L, $SO_4$ 9 mg/L, Li 9.04 mg/L, and B 0.3 mg/L (ibid.). To describe these low level concentrations as "significant" appears to be a fairly subjective call. Had these authors not been predisposed to augment the Hot Springs theory, they might have considered that these chemical species are commonly observed in cold mineral springs and are also liberated by the alteration of silicic ash. Some portion of these chemical species could also have been derived from fumarolic deposits on the original caldera floor. These authors stated that "Phillips and Van Denburgh, 1968, suggested that Cl and $SO_4$ found in Crater Lake water originated from thermal water" (White, et al., 1985). The abstract of the Phillips and Van Denburgh paper reads as follows: "Much of the dissolved-solids content of Crater Lake-especially the sulfate and chloride-may be related to fumarole and thermal-spring activity that presumably followed the collapse of Mount Mazama" (Phillips and Van Denburgh, 1968, p. 1). White, et al. (1985), also mentioned that these chemical species where "anomalously high" in comparison to nearby Diamond Lake. Again, I find this an inappropriate comparison because Diamond Lake was never a caldera floor. Diamond Lake does not have the potential for noncondensible gas influx that Crater Lake has, nor the constant influx of silicic ash that Crater Lake has. Diamond Lake may also have a significantly lower evaporation rate because it is 1000 feet lower in elevation and situated in a sheltered, N-S trending depression which affords less sun exposure.

Since invalid background comparisons were used by White, et al., 1985, to subjectively declare the small concentrations of Na, Cl, $SO_4$, Li, and B to be "anomalously high", and since these constituents have other plausible sources, it is only an assumption that they indicate hot spring activity.

The main objection I have to the contention that these chemical data "support the hypothesis that thermal water discharges into Crater Lake" (White, et al., 1985) is that the present lake chemistry is not necessarily reflective of current processes.

It is possible that some of these chemicals could have come from thermal water input at some time in the past, but that bears no evidence for the present. Hot springs have quite limited life expectancies, especially where they discharge into very cold, deep bodies of water. Even the large sea floor hydrothermal vents are estimated to have lifetimes on the order of tens of years (Macdonald, 1982, p. 175).

To circumvent this time problem consideration, the chemical modelers had to evoke the concept of a "chemical steady state lake" (Muffler, 1986a; Nathenson, PMT, 1987). Given the very brief pinch of time that the lake chemistry has actually been observed, this concept would have to be objectively viewed as a modeling convenience as opposed to logical assumption. Although the steady state lake concept was defended as being a "simpler and therefore better" perspective (Nathenson, PMT, 1987), it should be clarified that it only makes life simpler for the modelers but not Mother Nature. Undeniably, the lake has been progressively freshening with time. Initial inundations of caldera floors typically display total dissolved solids concentrations in the tens of thousands ppm, mainly from the dissolution of fumarolic deposits and influx of noncondensible gasses (Thompson, 1987). The "steady state lake" concept requires Mother Nature to obligingly halt this ongoing freshening process. This concept also burdens nature with the difficult task of carefully balancing the annual leakage loss of dissolved solids with an identical influx of identical chemical species. It is purely an assumption that this balance is actually taking place and only a guess that the assumed balance is provided by thermal water discharge.

The Legend gained in psuedo-credibililty when Michael Sorey, USGS, Menlo Park, announced at a Cascades workshop in May 1985, that he had calculated flow rates of 30-150 L/sec for the "thermal-spring discharge" at Crater Lake (in Guffanti and Muffler, 1985). Although the bases for this calculation were not mentioned in the publication cited, they were essentially three: 1) That the chloride content of Crater Lake is in steady state; 2) That all the chloride lost through leakage is replaced solely by thermal water inflow, and; 3) That the hypothesized thermal springs, situated in the throat of a degassing 6,845 year old caldera, would have chloride concentrations similar to hot springs discharging from fault zones in the 5 to 40 million year old volcanic rocks of the Western Cascades (Muffler, 1986a). (Note: These assumptions were Sorey's not Muffler's, Muffler only provided them to me).

Based on these three assumptions, Sorey calculated the flow rates required to maintain the assumed balance. I doubt that Michael Sorey ever intended that his number pushing should be used as evidence for the Legend, but that is essentially what the Park Service has done. In the National Park Service (NPS) listing of "significant thermal features" published in the February 13, 1987 Federal Register, Sorey's entirely hypothetical mathematical ruminations were cited as Significant Criteria as follows:

> "Extent-Hydrothermal vents are located on the south central floor of the basin of Crater Lake at approximately 1500 feet depth. 30-150 liters per second inflow of thermal water is estimated to enter Crater Lake" (NPS, 1987).

This instance illustrates the most serious pitfall of model mania; the basic assumptions are seldom carried with the conclusions. The assumption that currently active hot springs provide all the chloride in the lake, was modeled to determine flow rates, that were then used as evidence for the basic assumption. This is circular reasoning.

## OTHER POSSIBLE SOURCES OF CHLORIDE

It is possible that chloride has been concentrated in Crater Lake by evaporation. The estimate of evaporation loss by Ken Phillips (Phillips & Van Denburgh, 1968) was derived by subtracting the estimated seepage rate from the estimated recharge rate. The estimated seepage rate was made by observing the drop in lake level during a period when evaporation was assumed to be negligible (ibid.). This determination by subtraction resulted in an anomalously low evaporation rate attributed to Crater Lake. "The computed loss of 23 inches per year. . . is 10 inches less than the average annual lake evaporation in the area, not adjusted for altitude." (Phillips and Van Denburgh, 1968, p. E20). An estimate of 34 inches per year of evaporation loss for Crater Lake was obtained from regional evaporation maps (Simpson, 1970, p. 5196). This could also be viewed as a probable underestimate due to the unique caldera wind conditions and elevation of the lake. Since the average annual precipitation estimates are between 67 inches (Simpson, 1970) and 69 inches (Phillips and Van Denburgh, 1968) it is quite possible that the true evaporation loss of Crater Lake may actually exceed 50% of its annual recharge. Thus, it is quite possible that chloride is actually being concentrated by evaporation. This would be even more probable at times in the past when the lake was subjected to periods of warmer, drier climatic conditions (see Phillips and Van Denburgh, 1968, p. E9). Hydrogen isotope data suggests that "the lake water has been evaporated" (Salinas et al., 1984).

Another possible source of chloride could be salts that were originally deposited on the caldera floor by fumarolic and thermal spring activity following the collapse of Mount Mazama (Phillips & Van Denburgh, 1968, p. 1).

A significant input of chloride could come from the continual input of altered caldera wall rock into the lake (see Nelson, 1967, p. 843). Hydrothermal alteration of the older rocks exposed in the caldera walls and fumarolic alteration of the holocene tuffs and air-fall deposits are described by Bacon, 1983. These altered lithologies are repeatedly sloughed into the lake through mass-wasting processes and would undoubtedly contribute to the chloride content of the lake.

The hydrochemical breakdown of the Mazama ash and other volcanic particulate matter is another undeniable source of chloride input to the lake. The Mazama ash runs about 1,000 ppm Cl (Bruggman et al., 1987). "Nelson (1961, p. 30) concluded that deposits of colloidal clay derived from volcanic ash, reworked in places by submarine landsliding, have helped to seal the bed of the lake" (Phillips & Van Denburgh, 1968). Obviously Crater Lake is receiving chloride input every time the wind blows ash into the lake. "Wind transports materials such as pollen and pumice dust to the lake surface and moves these over the surface as a scum" (Nelson, 1961, p. 844). Montmorillonite, a clay mineral commonly formed from the alteration of volcanic ash (Berry and Mason, 1959, p. 509), is common in the clay-size fraction of Crater Lake sediments (Nelson, 1967, p. 839).

Cold mineral springs similar to those found throughout the Cascades could also be supplying chloride to the lake. A wide range of chloride concentrations is observed in these ambient temperature springs but Cl concentrations as high as 22,000 ppm have been recorded (Barnes, 1984).

Noncondensible gas influx could add chloride to Crater Lake, particularly since it resides in the throat of a volcanic vent. The significance of volcanic emanation of HCl gas has long been recognized (Zies, 1929). Stoiber and Williams (1984) reported 830 tons per day of HCl gas emanating from a non-erupting volcanic crater in Nicaragua. Any post-lake-filling gas eruptions and/or continuing seepage could have added to the chloride content of Crater Lake.

Another definite source of chloride input to Crater Lake is the leakage from the sewage facilities at Rim Village (Briggle, 1987). Since a tracer study has never been run on this leakage, no estimates of input volume are available; however, over a half million people visit Rim Village annually and urine is quite high in chloride.

### Chemical Homogeneity of Lake Water

Although Sorey's flow rate calculations constitute only an assumption because they assume that thermal vents facilitate an assumed and unrealistic steady state lake, they can be used to assess another contended line of evidence put fourth to support the Hot Springs Legend. Vertical profiles of lake water chemical composition show a fairly uniform composition with depth throughout the lake (Williams and Von Herzen, 1983). This uniform chemical composition was attributed to physical mixing (as opposed to chemical diffusion) and the hypothesized thermal spring discharge was assigned the task of convecting and thoroughly mixing the lake (ibid.). Thus the chemical homogeneity of the lake has been attributed to convection and labeled as evidence for thermal water discharge (White, et al., 1985).

Since Sorey's flow rate calculations ignore all other sources of chloride, they can be viewed as an absolute maximum volume that the hypothetical springs might be putting out. By converting Sorey's rates of 30-150 L/sec to an annual inflow volume, one finds that a whole year's supply of this hypothetical fluid would amount to 0.0055 to 0.027 percent of the total lake volume (LaFleur, 1987). Compared to the total volume of the lake, the midpoint of the 30-150 L/sec is equivalent to putting 1.5 drops per day of thermal water into a 44 gallon bath tub of ice water (ibid.). These calculations suggest that even the hypothetical maximum thermal water discharge could not have a significant physical effect on the lake. The deep water profiles taken in the Southwest basin did indicate that local convections of the deep waters can occur (William and Von Herzen, 1983, p. 1100) but, this would have to be primarily, if not wholly, through conductive heat transfer. The two areas of elevated heat flow identified by Williams and Von Herzen (Fig. 1) would warm local bottom waters to the point where they would eventually diapirically convect upward in a manner similar to the old lava lamps that continue to transfix patrons of obscure bars throughout the west. Because of warmer surface water temperatures (Fig. 4) these local upward convections could only reach mid-depth range (ibid., p. 1102). Since these two areas of elevated heat flow are relatively small compared to the lake, it is questionable how instrumental they are in mixing the whole lake. The drop in the bathtub calculation indicates that it is highly unlikely that lake mixing results from thermal water discharge.

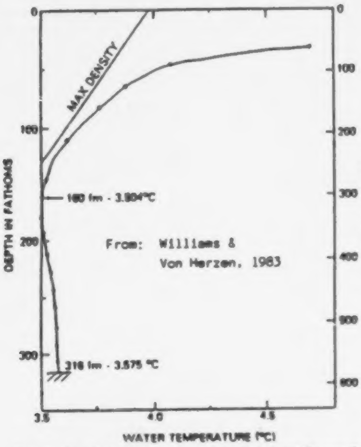


Fig. 4. Vertical water temperature profile from the east basin near Merriam Cone. The line labeled 'Max Density' is the curve of the maximum density from *Eklund* (1963).

## FURTHER PERPETRATION OF THE LEGEND

More recent declarations of hot spring "evidence" have been put forth by members of the National Park Service Cooperative Park Studies Unit at Oregon State University. "The presence of hydrothermal inputs to the deep lake was conclusively documented based on the discovery of a helium isotope anomaly." (NPS-CPSU, 1986, p. 31). "These data show helium isotopic anomalies more than 200% greater than the atmospheric value . . . As such it is conclusive evidence of current hot spring input into the lake" (Dymond, 1986). When I mentioned this claim that helium isotope anomalies supposedly provide "conclusive evidence" to Patrick Muffler, erstwhile Branch Chief of Igneous and Geothermal Processes, USGS, Menlo Park, he immediately retorted; "That's bullshit, and you can quote me on that" (Muffler, 1986b). Albeit a bit blunt, one must appreciate the unbiased accuracy of Muffler's response. The isotopes of helium ($^{3}$He and $^{4}$He) are extremely mobile noncondensible gasses that certainly do not require aqueous solution for vertical transport.

Professor Dymond also reported "We did measure $^{222}$Ra anomalies that were 3-10 times background. Although not conclusive this is strong evidence of hot spring activity" (Dymond, 1986). Dr. Dymond actually meant $^{222}$Rn (Radon). "A total of 24 radon samples were taken" (ibid.). Although not as mobile as helium, radon is a mobile noncondensible gas that most certainly does not require hydrothermal convection for transport. Radon detection "cups" are commonly used in soil gas sampling and in monitoring of radon seepage into homes and buildings. I suppose those unfortunate homeowners who have high radon determinations should look upon it as "strong evidence" of hot springs lurking in the carpets.

## THE PORTLAND MEETING - THE LEGEND EXAMINED

Due to the legislative turmoil arising from the hot springs theory, a two day meeting was convened in Portland, Oregon to discuss whether the hypothesized Crater Lake thermal vents actually constitute a "significant thermal feature" that would be jeopardized by geothermal development. The meeting was sponsored by the Pacific Northwest Regional Section of the Geothermal Resources Council and was facilitated by cooperation of the BLM, USGS, and the National Park Service. The intent of this meeting was to examine existing data and evaluate current hypothetical models. Scrutiny of the modeling was seemingly a bit overwhelmed by lengthy presentation of data.

Charlie Bacon, USGS, Menlo Park, gave a run-down on the caldera geology. Hans Nelson also USGS, Menlo Park, gave us a look at sedimentary processes affecting the lake floor, emphasizing turbidites from mass-wasting of the caldera walls. I presented some discourse on the absence of data or logic to support the chemical steady state lake concept. I presented the volume calculations (discussed above) that demonstrate the minimal physical effects the hypothetical hot spring flow rates would have. I also presented the undistorted deep water temperature profiles (Fig. 3) and suggested that they were actually produced by conductive heat transfer. I pointed out that the elevated temperature gradients measured by Williams & Von Herzen (1983) did not really indicate actual thermal water discharge because areas of ascending fluids would have isothermal profiles as opposed to the steep gradients recorded. At the end of my spiel I called for any dissent or disagreement with my contentions but received none (LaFleur, PMT, 1987).

David Williams, USGS, Denver, provided some highly pertinent clarification of the "thermal vent" issue. Williams pointed out that to a geophysicist like himself, any temperature above ambient was a thermal anomaly. Williams explained that the "thermal venting" he and Von Herzen had actually identified was on the order of 0.1°C above ambient and resulted from slow moving local convection of lake water; a phenomena that could not be affected by activities outside of the lake. (Williams, PMT, 1987)

The clarifications provided by Williams were somewhat offset by Manuel Nathenson, USGS, Menlo Park, who presented yet another model based on the assumption that an undocumented chloride balance in Crater Lake results solely from currently active hot springs and concluding that these hot spring vents would have temperatures from "23° to over 200°C" (Nathenson, PMT, 1987). In support of the basic assumption, Nathenson contended that "chloride cannot be leached from rock at low temperatures" (ibid.). One familiar with geochemical processes would realize that diagenetic alteration of the Mazama ash is undoubtedly taking place on the lake floor at less than 4°C and chloride would be liberated in this process. Mazama ash runs about 1,000 ppm chloride (Bruggman et al., 1987). Thus, a significant addition of chloride is observable everytime the wind blows ash into the lake. To ignore the observable and place full credit on the hypothetical is hardly scientific. Nathenson received a round of applause for his modeling efforts, but I was unable to join in for want of one hand which was scratching my head in befuddlement wondering how "23° to over 200°C" was supposed to lie flat on the bottom of a 4°C lake.

An exorbitant amount of time was spent on discussion of chloride values but it led to a consensus that, due to the error bars of analysis, no one could actually tell whether the chloride content of the lake was varying with time or not (PMT, 1987).

Nathenson also presented the data and conclusions from a 1983 AGU Poster by Michael Thompson and Douglas White, USGS, Menlo Park, entitled "Does Crater Lake Have a Discernible Outlet?" About 10 springs on the flanks of Mazama were analyzed for chloride, deuterium and oxygen 18. From my field work in the area, I would estimate there must be at least 500 springs on the flanks of Mazama, most of which are unmapped. Therefore it is about 2% correct to imply that the outlets of Crater Lake have been prudently sought. Quite apparently the USGS needs to proportion a higher percentage of its budget to field data acquisition.

Dave Blackwell, a heat flow authority from Southern Methodist University, presented a talk on data from Yellowstone Lake. Blackwell's talk illuminated the extreme differences between the very high heat flow values and elevated temperatures recorded in Yellowstone Lake contrasted to the tiny temperature variations recorded in Crater Lake.

Ivan Barnes, USGS, Portland, presented a talk largely focussed on the pneumatolytic transport of chloride as HCl gas. Barnes presented data and photographic evidence of this process, demonstrating that emanation of HCl gas is common to degassing volcanoes. This suggests that non-condensible gas influx could have provided chloride to the lake. Dr. Barnes also pointed out that any high temperature, high pressure discharge (as suggested by Nathenson's modeling) would be accompanied by discharge of $CO_2$ and a bicarbonate bloom in the lake water would be apparent. No such bloom has been reported.

On the second day of the Portland meeting, Dr. Douglas Larson, U.S. Army Corps of Engineers, Portland, presented data indicating a 25% loss of clarity in the lake and attributed this diminished clarity to the proliferation of a phytoplankton, probably facilitated by influx of nitrate nitrogen via sewage leakage from Rim Village. The National Park Service representatives in attendance were unable or unwilling to answer the question of why the repeatedly recommended sewage tracer study had not yet been initiated (PMT, 1987)

Bob Collier and Jack Dymond, two Oregon State oceanographers contracted by the Park Service to study the lake, presented chemical data and further comparison of Crater Lake to an oceanic spreading center. They contended that because $^{3}He$ and $^{222}Rn$ anomalies are found at sea floor hydrothermal vents, they evidence hot springs in Crater Lake. They also listed some common metallic cations observed in a few sediment cores and in the bottom lake water as hot spring evidence because they occur in anomalous concentrations at oceanic spreading centers. These cations included Al, Ba, Mn, V, P, Zn, and Fe. These cations and particularly iron were referred to as "hot spring tracers" (Collier and Dymond, PMT, 1987). Dr. Ivan Barnes objected to the reference to these cations as hydrothermal tracers because their mobilities are Eh/pH controlled as opposed to temperature controlled (Barnes, PMT, 1987). I would also add that these cations are not commonly employed in terrestrial geothermal exploration because they occur in a wide spectrum of geologic environments. Iron for instance, Dymond's most emphasized "tracer," is concentrated at ambient temperatures in such things as liesegang banding, red beds, hematitic ironstone, glauconitic sediments, and ordinary mineralized ground waters. Anyone who has observed iron stain build-up in their toilet bowl would question its validity as a "geothermal tracer". All of the elements cited by Dymond and Collier would be liberated by the diagenetic alteration of the Mazama ash and other volcanic particulates continually supplied to the lake (see Bruggman, et al., 1987).

Near the end of the meeting, there was some pertinent discussion on the geohydrologic setting. Ed Sammel, formerly USGS, Menlo Park, gave a short discourse that essentially identified Crater Lake as a perched water table in an area of regional recharge. There was some general discourse on the consideration that any thermal vents on the lake floor could not be in open communication with the regional water table (approximate elevation 4600 feet) because they would be repressed by the hydraulic head of the lake (elevation 6176 feet). For this reason, only local cells of convecting lake water, as theorized by Dave Williams, were considered realistically plausible. Therefore, there was a consensus that geothermal development on the flanks of Mazama outside of the park could not affect any thermal features on the lake floor (PMT, 1987).

A news release from the Associated Press on the meeting began, "Portland - Nearly 100 scientists agreed Wednesday that geothermal drilling near Crater Lake National Park would not harm the lake, but many believe evidence exists that America's deepest lake contains geothermal landmarks that should be protected" (Associated Press, 1987). Although seemingly paradoxical, this quote is accurate; hownver, without a score card the reporter was unable to distinguish the scientifically motivated from the politically motivated. The real paradox is that if there were actual hot spring vents in the lake, they most certainly would be deleterious to the clarity of the lake. When this assertion was emphatically made at the close of the Portland meeting and any dissent was called for, there was no disagreement, from anyone in attendance (PMT, 1987).

## THE LEGEND LIVES ON

Despite the fact that the "measured temperature anomalies near the bottom of Crater Lake are approximately 0.05° - 0.1°C" (Muffler, 1987), and despite the fact that these anomalies could not be relocated the next year (Williams, PMT, 1987), the Park Service continues to promote the Hot Springs Legend and clamor for unnecessary legislative protection. I say unnecessary because the local convection cells as originally theorized by the Williams and Von Herzen (1983) were descending and reascending lake water in a closed system. Therefore, even if these cells exist, they cannot be affected by activity outside of the park, and that was the consensus of the Portland meeting (PMT, 1987). Furthermore, all the features within the National Parks are already protected by a number of existing laws. Incredibly, the legend surrounding an unthreatened, already-protected 0.1°C anomaly, is unjustifiably impacting possible utilization of a preferred alternative energy resource on multiple use National Forest ground 7 miles away. This irrational result of hyperextended conceptual modeling has become an issue of significant importance to those local citizenry who would like to experience the employment and tax revenue benefits of geothermal development. It is is also important to you and I the taxpayer and to anyone concerned with the clarity of the lake. The Park Service has recently announced that the search for the Crater Lake hot springs is their Northwest Regional Office's No. 1 funding priority (Associated Press, 1987b). They plan to spend $400,000 to put a submarine in the lake to hunt the elusive prey (ibid.). I'm not particularly against extravagant research spending but I do think the Park Service has questionable spending priorities. "A 25 percent decrease in the optical clarity of Crater Lake water occurred between 1968 and 1978" (Salinas, et al., 1984). More recent data indicates continuing degradation (Larson, et al., 1985). Park Service septic facilities at Rim Village are leaking sewage into the lake (Briggle, 1987). Several highly qualified researchers have concluded that the loss of lake water clarity is quite possibly caused by an increase in phytoplankton due to increased nutrients supplied by the sewage leakage (Hoffman, 1984; Larson et al., 1985). The Park Service was made aware of this possible cause-and-effect relationship nine years ago (Larson, 1978) yet the flow of sewage continues (Briggle, 1987). Public Law 97-250, September 1982, directs the Secretary of the Interior ". . . to immediately implement such actions as may be necessary to assure the retention of the lake's natural pristine water quality." For the $400,000 cost estimate of hunting hypothetical hot springs, the Park Service could pipe the sewage off the backside of the hill to a lower elevation so it couldn't leak into the lake. The Park Service and their OSU oceanographers have been comparing Crater Lake to a "primitive ocean" (NPS, Federal Register, 1987). "The similarity to ocean conditions has prompted park officials to liken Crater Lake to a miniature laboratory where scientists can compare conditions found in the world's oceans" (Medford Mail Tribune, April 19, 1987). There is little scientific validity to these contentions. Crater Lake undoubtedly initially had much higher salinity due to fumarolic activity at the time of caldera collapse and the lake has been freshening with time. The lake is now fresher than any primitive ocean could have been. The oceans have become saltier with time through evaporation and are now about 35,000 ppm total dissolved solids compared to the 80 ppm TDS of Crater Lake. Crater Lake is between 4,244' and 6,176' above sea level whereas oceans are notably below sea level. The only apparent similarity between Crater Lake and an ocean is that both contain water and oceanographers. Spending tax dollars to make curious oceanographic comparisons while the lake continues to receive sewage is totally contrary to the mandates of Congress.

Although I would enjoy seeing photographs of the lake bottom myself, I would rather see the optical clarity and beautiful blue color of the lake maintained. Before $400,000 is spent in pursuit of the Legend, it may be financially prudent to review the validity of the purported "lines of evidence."

## EVALUATION OF "EVIDENCE"

Objectively, data cannot be viewed as valid evidence unless it is at least quasi-unique to the interpretation. If other interpretations are equally plausible, the data or observations cannot be considered as valid evidence.

Temperature gradients in the sediments: The steepened temperature gradients recorded illustrate conductive heat transfer as opposed to thermal fluid ascention. Areas where thermal fluids actually ascend demonstrate elevated, isothermal temperature gradient profiles. No elevated, isothermal profiles were reported (Williams and Von Herzen, 1983). Therefore, the heat flow anomalies provide no evidence for hot springs.

Deep water temperature profiles: The configuration and distribution of the deep water isotherms are more reasonably interpreted as local conductive heating of the bottom water as opposed to an actual hydrothermal vent "plume". Therefore, these profiles provide no reliable evidence of hot springs.

Helium and radon anomalies: Since these mobile noncondensible gasses emanate freely from the earth's crust without the assistance of aqueous transport, they provide no reliable evidence.

Chemical homogeneity of the lake: The maximum hypothetical thermal fluid discharge (annual flow rate of .0055 to .027 percent of the lake volume) would have negligible physical effect on the whole lake. Deep water convection is more logically attributable to conductive heat transfer. Therefore the observed chemical homogeneity of the lake provides no evidence of hot springs.

The 10 ppm chloride concentration of the lake: There are other potential and undeniable sources of chloride. It was only an assumption that the lake's chloride content is in a steady state balance and only an assumption that this balance is maintained solely by currently active hot springs. Therefore, the chloride content of the lake provides no reliable evidence for current hot spring activity.

The slightly elevated concentrations of common metallic cations on the lake floor: Since the mobility of these ions are Eh/pH controlled rather than temperature controlled, and since they very commonly occur in much higher concentrations in many mineralized non-thermal groundwaters and would also be liberated by diagenetic alteration of lake floor sediments, they provide no reliable evidence for hot springs.

The concentrations of Na, Cl, $SO_4$, and B in Crater Lake: The low levels of concentration of these chemical species cannot be decreed anomalous in comparison to local surface waters because that is an invalid background for comparison. Also, they could certainly come from sources other than hot springs (e.g. weathering of the ash, old fumarole deposits, cold mineral springs, etc.); therefore, they provide no reliable evidence for hot springs.

## LINES OF NEGATIVE EVIDENCE

Objective researchers evaluate and give equal weight to lines of negative evidence. So far the Crater Lake hot springs modelers have ignored this consideration.

They haven't been found: Perhaps the strongest line of negative evidence against the existence of hot springs is that they have not been found. "The fact remains that no one has ever observed, identified, or sampled a thermal spring on the floor of Crater Lake" (Muffler, 1987). In looking for "hot" springs the most definitive evidence is heat. Bear in mind that Williams and Von Herzen placed their highly sensitive heat probe all around the lake floor and yet failed to report any significantly elevated temperatures in the sediments and only a less than 0.1°C above ambient in the bottom water layer (Williams and Von Herzen, 1983). This 0.1 °C anomaly could not be relocated the next summer following its discovery (Williams, PMT, 1987).

A photographic survey of the "thermal area" was conducted but failed to locate any vents (ibid., p. 1098). If these techniques have successfully located hot spring vents in the vastness of the Pacific Ocean, why have they been unable to locate vents within the much more limited confines of Crater Lake? This consideration can objectively be viewed as circumstantial negative evidence.

Flat deep-water temperature profiles: If "hot springs" with temperatures of 23 ° to 200 °C (as suggested by Nathenson, PMT, 1987) were actually entering the cold, still depths of Crater Lake, the "thermal plume" would stick up like a sore thumb instead of lying flat on the bottom of the 4 °C lake (Fig. 3). Bear in mind that the depths of Crater Lake do not have strong oceanic-type bottom currents to facilitate rapid mixing. The absence of any significant vertical pluming is strong negative evidence against actual "hot spring" discharge.

Absence of anomalous $CO_2/HCO_3$: Hydrothermal systems of any significant magnitude ubiquitously exhibit large volumes of $CO_2$ (the reader is challenged to identify one that doesn't). Any "hot spring" discharge into the lake floor would have accompanying discharge of $CO_2$ and or $HCO_3$, and a bicarbonate bloom would be apparent (Barnes, PMT, 1987). Crater Lake water could be described as conspicuously low in $HCO_3$ with a concentration of only 34 ppm (Phillips and Van Denburgh, 1968). This is identical to the bicarbonate concentration of non-thermal Davis Lake, Oregon, but only a fraction of the bicarbonate concentration of Paulina Lake, Oregon (352 ppm $HCO_3$) and East Lake, Oregon (125 ppm $HCO_3$) (ibid.), both of which have near-shore hot springs. This absence of elevated bicarbonate in Crater Lake must be objectively viewed as very strong negative evidence against the existence of "hot springs."

Absence of anomalous dissolved silica: Another chemical constituent inherent to hot springs is dissolved silica. Crater Lake water runs between 10 and 18 ppm silica (Salinas, et al., 1984). Non-thermal Davis Lake has 19 ppm silica, whereas Paulina Lake has 46 ppm silica. (Phillips and Van Denburgh, 1968). I consider the absence of elevated silica in Crater Lake circumstantial negative evidence against the presence of hot springs.

No reports of secondary silica or carbonates in the sediments: The silica in any hot springs entering the cold lake floor waters would tend to rapidly precipitate out as secondary chalcedony. No secondary chalcedony or carbonate precipitates were reported in the sediment cores examined by the O.S.U. oceanographers and proclaimed to contain "chemical tracers" of hot spring activity (Dymond, PMT, 1987). Similarly, no secondary silica or carbonate precipitates were identified in the 130 sediment samples examined by Nelson (1967). The absence of these precipitates in the sediment samples is also considered circumstantial negative evidence against hot spring activity.

Low total dissolved solids: Another line of negative evidence against significant hot spring input that has been totally ignored by the chemical modelers is that Crater Lake is quite low (80 ppm) in total dissolved solids (Phillips & Van Denburgh, 1968). Although the chemical modelers insist that the chloride content of Crater Lake (approximately 10 ppm) is elevated greater than a full order of magnitude by hot spring input, they conveniently ignore the fact that Crater Lake shows no appreciably elevated level of total dissolved solids. Paulina Lake, Oregon, a caldera lake with observable hot springs, has an elevated chloride content of 2.8 ppm, but also an elevated total dissolved solids content of 366 ppm (ibid.). The ratio of Cl to TDS is 0.008 in Paulina Lake. If a similar ratio of chloride to TDS were reasonably anticipated, Crater Lake should have about 1250 ppm TDS. Therefore the considerably low TDS concentration of 80 ppm in Crater Lake constitutes strong negative evidence against significant hot spring input.

Isotope ratios: A significant line of negative evidence is that the isotopic composition of Crater Lake ( $\sigma D = -78.3$ and $\sigma^{18}O = -9.5$ SMOW) suggests evaporation of the water but does not suggest thermal input (Thompson, 1984).

Low level of seismicity: A line of logic which further argues against the Hot Springs Legend is that Crater Lake Caldera is relatively tectonically quiescent (see Jacobson, 1986).

> "Commonly the vertical conduit needed for hydrothermal fluids to vent is provided by an active fault or fracture zone. The circulating fluids carry large quantities of dissolved solids that precipitate as the fluids approach the vent area where they undergo rapid cooling and chemical changes. These precipitated minerals will eventually clog the conduit" (Williams and Von Herzen, 1983).

Even on the highly tectonically active oceanic spreading centers, hot springs only persist for tens of years (Macdonald, 1982). In the absence of recurrent active faulting or rifting on the floor of Crater Lake, ascending convection limbs would soon seal off through mineral precipitation. Descending limbs would probably plug up with the fine grained sediments and clay depositing on the lake floor. Therefore, the still, cold depths of Crater Lake may be considered a less than optimum place to look for hot springs.

## SUMMARY OF EVIDENCE FOR THE LEGEND

There is no reliable evidence that indicates the existence of thermal vents on the floor of Crater Lake. Objective review illustrates a far greater preponderance of negative evidence against the probability of hot springs than there is valid evidence for the Crater Lake Hot Springs Legend.

## CONCLUSIONS

Modeling techniques, when properly utilized are an asset to the geosciences; however, the current fad of model mania with disregard to the inherent pitfalls of modeling has become a liability and a detriment to prudent geological interpretation. These pitfalls include:

1) Model conclusions become detached from the basic assumptions that created and defined the model and thereafter are assessed independent of these assumptions.

2) Detached model conclusions are often used to support the very assumptions from which they were derived, thereby, producing circular reasoning as opposed to lines of logic.

3) Modelers tend to build upon each other's detached model conclusions without adequate evaluation of the original basic assumptions. This often produces a house of cards or an inverted pyramid of speculation based upon speculation. Far too often ad hoc composite models aren't put back together to see if the pieces really fit or if the hypothetical model results actually describe the observed.

4) The principle of "multiple working hypotheses" is commonly discarded in the modeling process.

5) Lines of negative evidence are usually ignored to facilitate simplistic modeling of complex subjects.

The discourse in this article illustrates how submission to all of these modeling pitfalls resulted in the birth, growth and propagation of the Crater Lake Hot Springs Legend.

## LA FLEUR, JOSEPH G.

The ramifications of this form of pseudo-science have initiated a costly political turmoil and an apparent misdirection of public concern which is now focused on the search for a legend as opposed to a mitigation of sewage leakage into Crater Lake and diminishing water clarity. Will the elusive Legend ever be captured? Expedition leader, Jack Dymond, sounds confident; "I think the submarine part of it is going to grab people's imagination " (Dymond, in Associated Press, 1987b).

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# STATEMENT

of

KENNETH PRESS NEMZER

California Energy Company, Inc.

CHAIRMAN OF THE GEOTHERMAL RESOURCES ASSOCIATION

Before the Subcommittee on Mineral Resources Development and Production

U.S. Senate

Committee on Energy and Natural Resources

in support of S.1006

The Geothermal Steam Act Amendment of 1987

Hearing July 14, 1987

## STATEMENT OF KENNETH PRESS NEMZER
## CHAIRMAN OF THE GEOTHERMAL RESOURCES ASSOCIATION

Mr. Chairman, my name is Kenneth Press Nemzer. I am Chairman of the Geothermal Resources Association (GRA), a trade organization which represents most developers of geothermal energy with respect to governmental affairs. I am also Vice President for Legal and Governmental Affairs of California Energy Company, Inc. That company, involved exclusively in geothermal development and power generation, holds a large number of geothermal leases in California and Oregon. The company is also developing the geothermal resource of the United States Navy at its Weapons Center at China Lake, California.

### I GEOTHERMAL RESOURCES ARE UNLIKE OTHER RESOURCES.

The natural limitations on use of geothermal resources make them unique. A geothermal resource for electric generation is limited by factors that include the following:

a) it can be used only at the location where it is found;
b) it can be used only after construction of an electrical generating plant;
c) it can be used only to satisfy a power sale contract;
d) transmission facilities must be available to carry away the power.

These limitations are in addition to burdens shared by other resources: the necessity for expensive exploration, development and production. When the ordinary burdens are supplemented by the extraordinary burdens of geothermal energy, uncertain times can create unacceptable risks for developers and their investors.

### II THE FORCES LIMITING GEOTHERMAL DEVELOPMENT ARE BEYOND THE DEVELOPER'S CONTROL

A geothermal developer cannot control the availability of power sale contracts or transmission lines. It is at the mercy of the economy, the energy supply, the utility policy, power transmission policy, geography, demography and other forces. When those forces have combined to make power sale or power transmission unavailable to a particular geothermal resource area, it is literally impossible for the geothermal resource to be developed commercially at that location, and similarly impossible for a developer to help himself.

### III GEOTHERMAL DEVELOPMENT IS NOT CONDUCIVE TO ABUSIVE PRACTICES

A speculator can make no capital from the circumstances which necessitate extensions of geothermal leases. Geothermal resources cannot be stockpiled or shipped. Futures in geothermal resources have no market. Purposely leaving geothermal resources in the ground for speculative purposes makes no economic sense. When an adequate market for geothermally generated power is available a resource will be developed; if not, the resource is worthless and, in fact, is a money sink.

### IV THE PROPOSED AMENDMENT LEAVES NO ROOM FOR FREELOADERS.

The proposed amendment requires substantial work and monetary expenditure from developers. Eligibility for lease extensions requires compliance with both lease and unit requirements, which are costly, and also requires the likelihood of future development. Developers will not make those expenditures of money and effort unless they intend to develop a commercial resource as soon as market conditions warrant. Moreover, this legislation does not relieve the developer of the royalty burden when the resource can be developed. There is little or no room for speculators or freeloaders to take advantage of this legislation.

## V LEGISLATION TO EXTEND LEASES IS AN IMMEDIATE NEED FOR GEOTHERMAL INVESTORS.

S.1006 provides a workable system for extending federal leases beyond their 10-year primary term provided that, if not producing, the leases have been the subject of substantial work and investment. Some members of the Geothermal Resources Association have leases in imminent danger of expiring, leases in areas which for economic reasons are not ready to have power plants built. The urgency of their need for an extension is evident. Other companies, including my own, have leases with most of their ten year terms left. They too have an immediate need for this legislation. The reasons for the need center around the type of investment decision that needs to be made in the geothermal industry. Peculiarities of this industry make short term leases especially unworkable, and make ten years leases, in geothermal schedules, short term.

## VI GEOTHERMAL DEVELOPMENT TAKES PLACE IN STAGES, EACH DEPENDENT ON THE OTHER

Geothermal is partly an extractive industry, in the sense that geothermal developers explore for, drill for and extract a resource. But unlike other resources, a geothermal resource cannot be transported; it must be used where produced. The on-site character can be an environmentalist's dream, since one need only avoid environmental hazards in that one spot; but that character can be an investor's nightmare. Geothermal production has several distinct operations and requires several distinct investments, but no investor realizes a penny of production income until all the steps have been financed, prepared, carried out and made successful.

The investor in geothermal resources, therefore, must do what investors least like to do: put his money, in large sums, to venture where return depends on other investors and on the circumstances of later years. That time factor is our focus here. The investor who finances the leasing of land from the Government and the investor who finances geothermal exploration on that land have to rely not only on the developer's ability to finance and complete the project all the way through exploration and development of the resource, plant-siting, plant construction, transmission line construction and finally sale of power; he must also rely on circumstances at the end of that road being propitious for selling power.

At every step along the way it has to appear to the other investors that circumstances will be proper for sale at the end, or the chain will be broken and the earlier investments made futile.

## VII THOUGH MOST EFFICIENT IN THE LONG TERM, GEOTHERMAL DEVELOPMENT HAS HIGH INITIAL COSTS AND MANY SOURCES OF DELAY.

Geothermal projects are costly at the outset. A production-size well is normally budgeted at upwards of a million dollars, and can end up costing three to four million. Temperature gradient holes typically cost one to three hundred thousand dollars. Plants cost one to two million dollars per megawatt capacity. All these steps must be integrated into a long term program, which means steep administrative costs. In short, the capital expenses to get a geothermal project and the power production set up are substantial. Even though geothermal energy is cost effective when successful, it is efficient because of the long lasting nature of the resource; in the short run it is costly.

Every risk factor over the lifetime of a geothermal project potentially deters investment at that stage, and also deters investment at every later stage in the process. The earlier the investment, the greater the risk, not only because the resource is unproven at first but also because more years and more opportunities for delay and adversity lie between the investment and the return.

Among the causes of delay are the following:

a) The national and regional energy situation, that which has now produced excess energy availability in a few areas, such as the Northwest.
b) The need for transmission capacity, sometimes involving construction of long power lines to areas of heavy power use. Examples are proposed new interties to California from the Northwest and Nevada.
c) Environmental delays. These can include not only environmental studies and preparation of environmental documents; in areas new to geothermal development, delays can occur as administrative agencies gear up to handle the special technology.

## VIII THE UNACCEPTABLE INVESTMENT RISK: LOSING THE LEASE.

Senate Bill 1006 will not cure or do away with most of the adversities faced by a geothermal investor. But it can assist with one very important risk; the risk of a lease expiring before power is produced.

Despite adversity, some investors are willing to push their money into the quest for geothermal projects, even in areas which will not need power for some time. But they will not do so if there is significant risk that, before their quest is finished, the resource will be snatched away. Of all the risks that is the hardest to swallow. Geothermal investors are of necessity long term investors, willing to let their money work for long years before it benefits them. They are encouraged by the knowledge that geothermal resources, so far as we can discover, will not soon physically and geologically dissipate; the resources are in place to stay. Leases, on the other hand, are human creations; and if the leases might dissipate unjustly, the investor will take his coin elsewhere.

The question of lease duration troubles investors at each stage of development. No one wants to fund geological and geochemical research, test holes, production sized holes, wells, gathering systems, turbines, power plants, transmission lines, or any other step if the duration of the lease is in doubt.

## IX NO FACTS APPEAR TO MAKE S.1006 UNDESIRABLE.

Given these facts, the converse question must be asked: Are any values served by not having the extension provisions of S.1006? With other types of resources it is important for the Government, as other landowners, to have strict time caps on non-productive leases. The land does the country no good if it lies unused; and in the case of other resources, one might think that a developer who has not produced after ten years will not produce. But that is not so with geothermal. The circumstances here described, requiring enormous patience on the part of investor and a confluence of circumstances favoring each part of development, mean that one who has held the land for ten years is still probably the one to develop it thereafter. If the ten year holder has devoted significant work, that developer is the one to be relied upon after the ten year period.

Another reason given to terminate some leases is to free the land to other users. But geothermal development is compatible with other uses; and leases need not be curtailed to accomplish multi-use goals.

If a lease were terminated after ten years, any succeeding lessee would face the same economic circumstances which, by hypothesis, have delayed development to that date. Moreover, a new lessee would not have the investment already in it. It would not have investors telephoning, scowling at the company's financial reports, showing the expressions of impatience that investors always do when their money is in the ground and no return has come. It is that very impatience, from the investors whose indulgence made the project possible, that gives rise to the likelihood that the project will be completed. If the investors' optimism and patience ever turned to apathy, at that time the investors would no longer stand for the rental to be paid, and the property would be abandoned. If abandoned there is no need for a termination date.

## X CONCLUSION

We ask you to focus on the premise that geothermal investors, given the chance and given the conditionally renewable lease, will make projects work. That is in the history of the geothermal industry: pioneers who invest and work year after year, sometimes a decade and more, and finally produce this clean, efficient, domestic resource. It is for those investors that the Geothermal Resources Association asks you to enact S.1006.

Greater Yellowstone Coalition

Statement of

LOUISA L. WILLCOX,

PROGRAM DIRECTOR

for the

GREATER YELLOWSTONE COALITION

to

SENATE SUB-COMMITTEE

on

MINERAL RESOURCES DEVELOPMENT AND PRODUCTION

on

S.1006, GEOTHERMAL STEAM ACT AMENDMENTS OF 1987

**P.O. Box 1874 • Bozeman, Montana 59771 • (406) 586-1593**

The Greater Yellowstone Coalition submits the following comments on S.1006, Geothermal Steam Act Amendments of 1987. GYC is a coalition of 50 national, regional and local conservation organizations and approximately 1500 individuals committed to preserving the integrity of the Greater Yellowstone Ecosystem, one of the last remaining intact ecosystems in the continental United States. We appreciate the opportunity to submit our views on this important bill, which could have major impacts on the future of Yellowstone and its irreplaceable geothermal wonders.

Yellowstone is the largest remaining intact geyser basin in the world, and one of only three major geyser systems that have not been destroyed or damaged by geothermal development. Congress has clearly demonstrated its commitment to protecting this resource for future generations through the passage of Public Law 99-591. This bill withdrew from leasing and development activities the Island Park Known Geothermal Resource Area around Yellowstone Park, and required that significant geothermal features listed by the Secretary of Interior be carefully monitored. Because of its close proximity to geothermal features of Yellowstone National Park, and the possibility of damage to Park resources should geothermal development occur, the Island Park area should remain off limits to geothermal leasing and development.

The Greater Yellowstone Coalition appreciates the commitment and leadership exercised by Senator Melcher in securing this withdrawal and protecting Yellowstone National Park from development in the Island Park area. We also appreciate the conscientious approach taken by the National Park Service to protect Yellowstone's geothermal heritage on these federal lands.

GYC is concerned, however, that the protection currently awarded to the Park's geothermal systems is not adequate in several important areas. We recommend that S.1006 be amended to address these concerns so that Yellowstone becomes, as it should, a model of protection for its internationally prized hydrothermal resources.

At this time, the specter of potentially harmful geothermal development looms over private and state lands, both in Island Park and on other federal and private lands around Yellowstone National Park. Although little is known about the interconnections of the aquifers between the thermal areas inside and outside Yellowstone Park, USGS and

NPS geologists have concluded that drilling and pumping of geothermal areas surrounding the Park could impact the Park resources themselves. These geologists have also noted that there could be a lag time between development and future deterioration of geyser systems, and that this damage may not be reversible.

GYC firmly believes that any risk is unacceptable where such national treasures as Yellowstone Park and its geysers are concerned. Ongoing development activities by the Church Universal and Triumphant (CUT) on their property in Corwin Springs pose the most immediate threat to the geothermal integrity of the Park. Because of the proximity of LaDuke Hot Springs to the Mammoth Geyser Basin, and the concern that the two areas may share the same underground aquifer, GYC recommends that the Corwin Springs Known Geothermal Resource Area should be immediately withdrawn from all geothermal development as part of a 15-mile buffer area around Yellowstone.

GYC also urges the amendment of S.1006 to withdraw a 15-mile buffer area around Yellowstone Park, including private, state and federal lands, with the understanding that this zone would be tailored to the recommendations of the National Park Service and U.S. Geologic Survey once they complete the required research to determine sensitive areas outside the Park. This 15-mile withdrawal area was previously recommended by several National Park Service directors, and would, according to USGS experts, reasonably protect the Park's resources until the time that specific geothermal relationships have been determined and vulnerable areas have been identified and formally withdrawn from development.

GYC is also concerned about the dangers posed by oil and gas exploration and development to the geothermal resources of the Greater Yellowstone Ecosystem. According to USGS geologist Irving Friedman, oil and gas exploration and development could be a more serious long-term threat to the Park's geothermal areas than geothermal development. The reason is that in geothermal development, most of the fluids are reinjected into the source wells after extraction, whereas in oil and gas development reinjection does not occur. This may create underground voids, which could precipitate subsidence, earthquakes and other disturbances which could irreversibly alter the flow of water within the geothermal system. Enclosed is a more complete explanation of the hazards of oil and gas development, submitted in a 1979 memo to the National Park Service by Irving Friedman.

Oil and gas leases currently ring Yellowstone National Park in the Island Park Geothermal Area, in portions of the Corwin Springs Geothermal Area, and in the southern part of the Gallatin Range. Some geologists believe that the deep water feeding the thermal areas in Yellowstone originates north of the Park in the Gallatin Range -- where some leases presently occur. (Enclosed is a copy of Yellowstone Under Siege, a report issued by the Sierra Club that shows areas leased for oil and gas in the Greater Yellowstone Ecosystem). In light of the severity of the risks involved in oil and gas development around Yellowstone Park, GYC recommends that S.1006 be amended to include a withdrawal of all oil and gas leasing and development in the recommended 15-mile buffer area around Yellowstone Park.

Another area of substantial concern is the lack of funding for the essential geothermal research and monitoring in and around Yellowstone Park. Although clear direction was given by Congress to thoroughly study the relationships between areas inside and outside Yellowstone National Park, the available funds for this purpose have been exceedingly limited, and projected budget limitations could prevent this necessary work from being completed. GYC recommends that Congress assure the full funding required to extensively research and monitor all geothermal areas around Yellowstone Park so that baseline data can be established. This data will be essential to detect and assess hydrothermal changes, and initiate corrective actions.

GYC also opposes provisions in S.1006 that allow a lessee to extend the lease term for successive five-year periods. Since Yellowstone is the nation's first national park and the last great example of an intact geyser system in the country, it should be treated as a model of Park protection. Thus, any extension of leases that facilitates geothermal development around Yellowstone National Park is simply not necessary, and should be prohibited. Rather, in the Greater Yellowstone Ecosystem, the Department of Interior should be directed to acquire existing geothermal leases from all current lease holders on private, state, or federal lands. Only through the acquisition of existing development leases can the federal government assure that Yellowstone National Park and its geothermal wonders will be thoroughly protected in perpetuity.

In summary, GYC requests that S.1006 be amended to include the following provisions concerning the Greater Yellowstone Ecosystem:

1. The institution of a 15-mile buffer area around Yellowstone Park, where geothermal *and* oil and gas leasing and development will be prohibited in order to protect the Park's geothermal resources, with the understanding that this zone would be modified according to the findings of subsequent USGS and NPS research;

2. The authorization of a *fully funded* comprehensive study by NPS and USGS of the geothermal resources inside and outside Yellowstone National Park, designed to assess geothermal relationships and to identify sensitive areas which would be placed off limits to geothermal and oil and gas and possibly other types of development;

3. Acquisition of all existing geothermal leases in sensitive areas on state, private and federal lands identified by USGS and NPS in the study discussed above.

The Greater Yellowstone Coalition appreciates the opportunity to submit these comments.

REC'D MAR 3 9 1987

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Branch of Isotope Geology

IN REPLY
REFER TO:

January 13, 1986

To : Lorraine Mintzmyer
Regional Director, NPS

From : Irving Friedman, Research Geochemist
Branch of Isotope Geology

Subject: Threat associated with gas and oil development adjacent to
Yellowstone National Park

In response to your request regarding the above, my assessment follows:

As you are aware, oil and gas leases have been granted by the Forest Service on the west boundary of the Park in the Gallatin National Forest. The Park is in the overthrust belt which is an area of high petroleum potential.

Gas and oil development represents a threat to the thermal features of the Park at least as important as geothermal heat extraction. Geothermal operators can be made to, and actually may desire to reinject the geothermal fluids back into the aquifer. The result is that heat is removed from the system, but little fluid is lost. Other than the possibility of causing earthquakes by reinjection, there are minimal tectonic effects from such activities. Without minimizing the effect that heat extraction from the Island Park area might have on the geysers and hot springs of Yellowstone, gas and oil development also has great potential for damage.

Large scale petroleum extraction removes material from the subsurface and together with the possible reinjection of oil field brines can result in tectonic changes such as ground subsidence and earthquake generation, in addition to the possible alteration of subsurface flow to adjacent thermal features. Research in the Rangely, Colorado oil field has documented the influence of fluid injection in triggering earthquakes. ("An experiment in earthquake control at Rangely, Colorado" by C. B. Raleigh, J. H. Healy and I. D. Bredehoeft. Science vol. 191, 1230-1237, 1976).

Land subsidence caused by gas and oil extraction is well documented. For example, see "Subsidence over oil and gas fields" by J. C. Martin and S. Serdengecti, Reviews in Engineering Geology, vol. VI, 1984, Geological Society of America (see attached).

At present, little is known of the subsurface interconnections of aquifers between Yellowstone and its surroundings. This information is difficult to obtain without extensive drill hole data.

Recently reference has been made of a research report in which the authors postulate that the deep water feeding the thermal areas in Yellowstone originates north of the Park in the Gallatin Range. "The effects of subsurface boiling and dilution on the isotopic compositions of Yellowstone thermal water" by A. H. Truesdell, M. Nathenson and R. Rye - Journal of Geophysical Research, v. 82, P. 3694-3704 (1977). For a number of reasons, I take issue with the authors conclusions. I do not think that the Park can depend upon this supposed connection to the north to rule out impact from development to the west of the Park, nor in fact from any direction.

cc: Robert Fournier
Lynn Torak
John Rosholt

J. N. Rosholt
Subactivity RF
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✓IFriedman:mav

# YELLOWSTONE UNDER SIEGE

## Oil and Gas Leasing in the Greater Yellowstone Region

July 1986

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Cover photo:
*The Grand Canyon of the Yellowstone River in Yellowstone National Park. In some parts of the park oil oozes out of the ground. The park itself is off limits to oil and gas leasing but the federal government has leased millions of acres of adjacent public lands. Photo by Philip Hyde.*

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Ralph Maughan

## 3

# OIL AND GAS LEASING IN THE GREATER YELLOWSTONE REGION

## Summary

The complex beauty that we know as Yellowstone National Park is threatened. The threat comes not only from overuse, lack of maintenance, or the multiple human impacts within the park, though these are important, but from development outside the park boundaries that threatens the viability of the wildlife and natural resources for which the park is justifiably famous. This report is about one such threat – one that we believe may be the most severe – indiscriminate oil and gas leasing, exploration, and development in the area around Yellowstone.

A small corner of North America when seen on a map, Yellowstone is one of our most extraordinary natural treasures – one of the largest intact ecosystems in the temperate zone, where an abundance of wildlife lives amid a geologic wilderness of mountains, waterfalls, and geysers. Yellowstone National Park itself is only a small part of this natural system – designated by ecologists as the Greater Yellowstone Ecosystem.

Since the park's establishment in 1872, Congress has moved to protect other parts of this fabulous area through the establishment of Grand Teton National Park, the National Elk Refuge, the Red Rock Lakes National Wildlife Refuge, and several federally protected wilderness areas on surrounding national forest lands.

Today we know that the boundaries of the two national parks do not even come close to enclosing the full natural area upon which the health of the parks and their wildlife is based. Wildlife, including grizzly bears, elk, and bald eagles, regularly leave the sanctuary of Yellowstone and Grand Teton national parks to live out portions of their life cycles on adjacent national forest lands.

In fact, the biological health of Yellowstone and Grand Teton national parks depends on the integrity of the surrounding national forest lands. It is here in these forests that the conflicts with leasing for oil and gas are of greatest importance.

We have confined this study to the six national forests adjacent to Yellowstone National Park – the Beaverhead, Gallatin, and Custer in Montana; the Shoshone and Bridger-Teton in Wyoming; and the Targhee in Idaho. Aside from the park lands themselves, these forests comprise approximately 95% of the Greater Yellowstone Ecosystem. As a consequence of their high environmental sensitivity, and the interest they inspire in the oil and gas industry, they represent an alarming case study of the problems inherent in current federal policies for oil and gas planning, leasing, and management.

For much of its extent, the Greater Yellowstone area overlies the Western Overthrust Belt, an area considered promising by oil and gas geologists. Present and past federal mineral management practices have led to the leasing of hundreds of thousands of acres of sensitive lands throughout these national forests.

Almost two-thirds of the forest land surrounding Yellowstone is open to leasing, and of this available land, 83%, or almost half of the total area, has already been leased. Four of the five entrance routes to Yellowstone have been leased. Essential grizzly bear habitat is open to leasing, as is a nearly 30-mile-long strip adjacent to Yellowstone National Park's northwestern boundary.

Under the current policy of the Department of the Interior, which has overall authority for leasing on most national forest lands, these leases represent a clear commitment to allow the full development of any petroleum resources found through exploration. Yet, as we will show in this report, these leases have been issued in a near total absence of consideration of the potential effects that the development of a successful find might have on the parks, the refuges, the forests, or their wildlife.

Many of the present leases were issued on the basis of environmental assessments that were essentially no more than long press releases announcing the preordained decisions. Yet, despite the fact that all six of Yellowstone's surrounding forests are currently in the process of adopting integrated forest plans, the level of attention given to oil and gas leasing has improved very little.

Although it would be an outrage for any of these forest plans to allow timber companies to log every wooded acre outside of congressionally protected wilderness, only two of the plans exclude any lands not already statutorily off limits to mineral development from oil and gas leasing and development. The plans are completely inconsistent in dealing with such key issues as the leasing of prime grizzly bear habitat and the management of forest areas directly adjacent to the parks.

Both the U.S. Forest Service and the Bureau of Land Management (BLM) appear to believe that the environmental consequences of development should be examined only when a lessee submits an application for a permit to drill (APD), and that any such consequences can be mitigated through the use of appropriate lease stipulations. However, once a lease is granted and an APD is applied for, the government argues that it cannot stop development because the lease grants an

*The Bureau of Land Management issued a lease to Exxon on this meadow at the entrance to Grand Teton National Park. After a public outcry, the BLM acknowledge it had issued the lease by mistake and attemped to cancel it, but Exxon appealed the cancellation.*

exclusive right to develop. As a result, thegovernment has adopted a policy that effectively prevents meaningful multiple-use decisionmaking that would balance the commitment to allow development ofoil and gas with other potential resource uses of the national forests and BLM lands.

This absence of planning can have serious consequences. As shown in Part II of this report, although the consequences of oil and gas exploration and development can be effectively mitigated in some cases, this development can and does have severe and unacceptable environmental impacts on sensitive lands.

The exploration and development of oil and gas leases involves repeated seismic blasting, road grading for hauling heavy equipment, land clearance and construction of exploration wells, construction of sump ponds for the disposal of drilling muds and toxic brines, and, in the case of the development of a commercial field, the construction of utility corridors, more roads, extraction facilities, and pipelines.

*Residents of Jackson Hole, Wyoming are concerned that oil and gas drilling will disturb sensitive wildlife and threaten the local tourist-based economy. Getty Oil is doing the drilling at this site. Grand Teton National Park is in the background.*

Philip Hocker

The impacts of this industrial activity often include surface disturbance over wide areas, displacement of wildlife, sedimentation and pollution of mountain streams, and the development of formerly roadless areas, including the introduction of heavy human traffic in what was once wild backcountry.

The leasing history of the Yellowstone area reflects a series of problems in the federal oil and gas leasing system generally:

- Despite the statutory discretion of the Secretary of the Interior not to lease, both the BLM and the Forest Service have adopted policies that, with few exceptions, result in leasing all lands not formally withdrawn from mineral entry by Congress.

- Land managers rarely develop adequate information or environmental analyses prior to leasing decisions.

- The environmental review conducted in connection with applications for permits to drill (APDs) is normally confined to the projected impacts of a single well and is, in general, inadequate to evaluate the potential cumulative impacts associated with successful oil and gas development in sensitive areas.

- In an attempt to mitigate the damage from development on lands that never should have been leased in the first place, land managers place extraordinary and unwise reliance on the blanket use of lease stipulations.

- The division of lease issuance and administration responsibility between the BLM and the Forest Service leads to uncertainty on the part of the public, and of agency decisionmakers themselves, as to their respective authorities and duties.

- Neither the Forest Service nor the BLM provides adequate public notice and opportunity for comment on proposed actions.

David Sumner

*Summer range, calving areas, migration routes and critical winter range for elk have all been leased by the federal government.*

## Recommendations

The Sierra Club recommends some specific actions that should be taken to prevent damage to the Yellowstone area from indiscriminate oil and gas development:

- No leasing should be allowed in critical grizzly bear habitat.
- No leasing should be allowed in bighorn sheep lambing areas, elk calving areas, or in elk and bighorn sheep winter range.
- No leasing should be allowed within the viewshed of Yellowstone and Grand Teton National Parks, within the viewshed of the entrances to the parks, within heavily used recreational areas, or within the viewsheds of communities economically dependent on tourism.
- The six national forests and the National Park Service should cooperate in preparing an integrated plan for mitigating the consequences of oil and gas development on lands already leased in the Greater Yellowstone Area. The National Park Service must be directly involved in a cooperative effort to manage existing leases and to plan future leasing in a manner best designed to protect park values.
- The six national forests in the Greater Yellowstone area should develop cooperative and consistent leasing plans and policies and should prepare supplemental environmental impact statements, in order to integrate oil and gas leasing and management decisions with their overall forest plans.

In addition to these specific recommendations, the Sierra Club recommends several legislative actions we think are necessary to provide adequate controls on the development of public lands for oil and gas resources:

- integration of minerals planning with the management of other values on the public lands, including area-wide mapping of planned leasing decisions, consultation with state and local governments, and an examination of cumulative impacts of development prior to leasing;
- institution of a clear policy to lease only those lands which, after study, are considered suitable for oil and gas development, or suitable for such development under specific protective stipulations;
- designation of the Forest Service as the primary authority for issuance and administration of oil and gas leases on national forests;
- establishment of procedures to provide meaningful public notice and opportunity for comment on agency intentions to issue leases or to approve permits for seismic or drilling operations on leases; and
- termination of the simultaneous oil and gas lottery system and establishment of a competitive leasing system for oil and gas resources on public lands.

# I. The Extent of Oil and Gas Leasing in the Greater Yellowstone Region

## Introduction

Oil and gas exploration is not new to the national forests surrounding Yellowstone National Park. The first exploratory well was drilled on the Bridger National Forest in March 1929. In 1949, an exploratory well was drilled in Carrot Basin in Montana's Gallatin National Forest, only 12 miles from the west entrance to Yellowstone National Park.

During the 1940s, oil and gas exploration near Jackson Hole, Wyoming, caused such intense public controversy that Secretary of Interior Julius Krug withdrew from mineral leasing the lands north of the 11th Parallel in the Teton National Forest adjacent to Yellowstone.

Although oil and gas exploration is not a recent phenomenon in the Yellowstone area, the vast scale of leasing and the current accelerated pace of exploratory drilling are new features. Only good fortune is protecting the park and its surrounding lands, and the wildlife dependent on them, from the potentially severe impacts of intensive oil and gas development.

This section of the report examines the extent of oil and gas leasing and exploration in the Yellowstone area.

## Millions of Acres Leased – Over a Million More Pending

All or part of six national forests lie adjacent to Yellowstone and Grand Teton national parks – Bridger-Teton, Targhee, Gallatin, Custer, Shoshone, and Beaverhead. Of the national forest land in the area, 59.7% – 5.9 million acres – is presently open for oil and gas leasing (Table 1). In fact, a total of 4.7 million acres – 79.9% of the area available for leasing – is already under lease or lease application.

In addition to the land already under lease, over one million acres of lease applications will be processed upon completion of the forest plans and upon the resolution of a lawsuit involving the oil and gas leasing process of the Gallatin National Forest. With so much public land open to leasing and in fact already leased, oil and gas development has the potential of having the single greatest environmental impact in the Greater Yellowstone area.

TABLE 1.

Oil and Gas Leasing in the National Forests Around Yellowstone National Park

| National Forest | Acres Adjacent to Yellowstone N.P. (% of forest) | Acres Open to Leasing | Acres Leased or with Lease Applications | Acres Withdrawn from Leasing by Congress | Acres Forest Service Has Chosen Not to Lease |
|---|---|---|---|---|---|
| Beaverhead | 565,120 (30%) | 456,320 | 254,289 + | 108,800 | 0 |
| Bridger-Teton | 3,400,549 (100%) | 2,051,500 + | 2,200,000 | 1,255,637 | 93,370[1] |
| Custer | 527,360 (10%) | 188,360 | 188,000 | 339,000 | 4,000 |
| Gallatin | 1,412,212 (80%) | 642,000 | 516,000 | 739,000 | 32,040[2] |
| Shoshone | 2,433,125 (100%) | 934,990 | 800,000 | 1,422,735 | 75,400[3] |
| Targhee | 1,483,165 (80%) | 1,338,000 + | 724,480 + | 130,535 | 0 |
| TOTALS | 9,821,531 | 5,611,170<br>(57.1%) | 4,682,769 +<br>(47.7% +) | 3,995,707<br>(40.7%) | 204,810[4]<br>(2.1%) |

**Footnotes**

[1] 43,370 "scenic" acres close to Jackson, plus about 50,000 acres of Situation I grizzly habitat.

[2] The Madison Canyon Earthquake Geological Area. Authority to lease this area is reserved for the chief of Forest Service.

[3] All Situation I grizzly habitat.

[4] Not including minor acreages for administrative sites and campgrounds.

## Critical Areas That Have Been Leased

With very few exceptions, congressionally designated wilderness areas, which are formally withdrawn from mineral leasing, are the only national forest lands off limits to oil and gas exploration and development in the Yellowstone region. This leaves many critical areas open to leasing and exploratory drilling, including the scenic entrance corridors to the park and many candidate wilderness areas on the national forests. Four of the five entrances to Yellowstone National Park are either leased or open to leasing. This is particularly significant, since all of these corridors are heavily used for recreation and are an important part of the experience for the two million visitors who come to Yellowstone every year.

Other examples of key areas already leased or open to leasing include:

### BEAVERHEAD
### NATIONAL FOREST
### MONTANA

### Madison River

On the Beaverhead National Forest, the headwaters of the West Fork of the Madison River are under lease. The West Fork is the major tributary to the main Madison River, which is one of the most famous blue ribbon trout streams in the nation. In recent years, increased sedimentation from logging in the West Fork's drainage has begun to impact the river's pristine waters. Uncontrolled oil and gas development, with large drill pads and new access roads, can only add to this problem.

### Gravelly Range

Rangers in the Beaverhead National Forest predict that, within the next several years, wildcat drilling will begin on existing leases in the Gravelly Range. Sediment from washed-out roads and logging areas has already degraded trout spawning reaches on the West Madison River. More siltation can be expected to result from road grading for oil and gas development.

### Red Rock Lakes National Wildlife Refuge

Much of the national forest lands surrounding the Red Rock Lakes National Wildlife Refuge, home to the trumpeter swan, have been leased.

### BRIDGER-TETON
### NATIONAL FOREST
### WYOMING

### Jackson Hole

The Bridger-Teton National Forest has seen more exploratory drilling than any other forest in the Yellowstone region, with 151 applications for permits to drill (APDs) granted since exploration began in 1929. More than four dozen of those APDs have been located in Teton County itself, the home of Jackson Hole, Grand Teton National Park, and much of Yellowstone.

### Mt. Leidy Highlands

Essential grizzly bear habitat has been leased in the Mt. Leidy Highlands, which lie adjacent to the eastern boundary of Grand Teton National Park, just south of the Teton Wilderness. During 1985, an exploratory well turned up what may be a commercial gas find in the Highlands, only 30 miles from Yellowstone's southern boundary and 15 miles from Grand Teton's eastern edge.

### Gros Ventre Wilderness

To the south of Mt. Leidy, 45,000 acres of the newly designated Gros Ventre Wilderness are under lease. Proposals to drill in the Gros Ventre near Jackson, Wyoming, have been the source of much controversy over the last five years. Several wells have already been drilled on the periphery of the Gros Ventre, at least one of which was capped after showing promising signs of natural gas.

### CUSTER
### NATIONAL FOREST
### MONTANA

### Beartooth Highway

Much of the 10% of the Custer National Forest in the Yellowstone region is protected in the Absaroka- Beartooth Wilderness. Nearly all this land outside of the wilderness area, including popular car camping areas in the northern canyons, is leased or under lease application.

CBS News commentator Charles Kuralt has stated that the Beartooth Highway between the town of Red Lodge and Yellowstone's northeast entrance is "the most scenic highway in America." Visitor statistics reinforce his opinion, with almost a quarter million tourists using the highway during its short summer season. Although a quarter-mile-wide strip of public land on either side of the Beartooth Highway is leased with no-surface-occupancy stipulations to protect the view, drilling is planned to begin on private inholdings adjacent to the highway in 1986.

The proposed Line Creek Plateau-Deep Lake Wilderness to the east of the highway is leased and has been explored extensively by seismic crews since 1983. The Custer National Forest plan predicts wildcat drilling on both the Line Creek Plateau and the Red Lodge Creek Plateau to the north of the highway within the next ten years.

### GALLATIN
### NATIONAL FOREST
### MONTANA

### West Entrance to Yellowstone National Park

On the Gallatin National Forest, 40,000 acres of land adjacent to the Park's west entrance have been leased. The leases on the Hebgen Lake Ranger District include lands directly adjacent to the park boundary, and include important habitat for grizzly bears, bald eagles, and trumpeter swans. Two exploratory wells were drilled here, near the town of West Yellowstone, in the late 1950s.

### North Entrance

"Situation I" grizzly habitat (presently occupied and essential for survival) is leased around the north entrance to the park. In its forest plan for the Gallatin, the Forest Service recommends releasing the 155,000 Gallatin Range from its wilderness study status, opening more than 131,000 acres to leasing. This includes more grizzly bear Situation I habitat adjacent to the park and the area geologists believe to be the major groundwater recharge region for the geyser basins in the northern portion of Yellowstone.

If the Gallatin plan's recommendations are accepted, a strip of national forest land nearly 30 miles long adjacent to the park boundary will be open for oil and gas leasing.

## SHOSHONE NATIONAL FOREST WYOMING

### Eastern Entrance

During the last several years, controversy has swirled around the recently completed North Fork Well, which was drilled near the east entrance to Yellowstone Park. After intense public pressure, no new roads were built to the well site and only helicopter access was allowed. Other controversies – such as the current dispute over leasing and seismic blasting along the South Fork of the Shoshone River – are sure to arise in the future, since virtually all the non-wilderness lands along the 25-mile-long road corridor between Yellowstone's east entrance and Cody is under lease.

Photo courtesy of High Country News

*Leasing threatens bald eagle habitat.*

## TARGHEE NATIONAL FOREST IDAHO

### Palisades Roadless Area

On the Targhee National Forest, most of the Palisades Further Planning Area directly to the south and west of Grand Teton National Park is under lease. This extremely scenic area, which has seen several exploratory wells, serves as an important component of the watershed of the Snake River. The Snake, south of Jackson Hole, has been considered for years as a prime candidate for wild and scenic river status and is one of the most heavily used whitewater rafting rivers in the West.

---

The possibility of the development of one or more oil and gas production complexes in the Greater Yellowstone area can no longer be ignored. With so many critical areas on public lands surrounding Yellowstone under lease, the traditional Forest Service argument that "only one out of ten leases are ever developed" offers little consolation to those concerned with the long-term welfare of this precious natural resource.

In fact, if that argument were to hold true, the next ten years could see significant surface disturbance on over half a million acres of forest land in this highly sensitive area.

As is shown in Part III of this report, which deals with the current round of forest plans, and in Appendix B, which details the dismal history of past environmental review, there has been little or no meaningful planning preceding the wholesale commitment of these forest lands to potential oil and gas development. There has been no coordinated planning of any kind to guide the Forest Service, the Park Service, the U.S. Fish & Wildlife Service, and the Bureau of Land Management in protecting the Yellowstone region and its wildlife from the potential impacts of large-scale oil and gas development.

Even if such planning were to be undertaken now, the ability and willingness of the Forest Service to restrain development on lands already under lease is far from clear.

First, the actual decisions on leasing, exploration, and development of federal oil and gas resources underneath most national forest lands are made by agency officials in the Department of the Interior – not by the Forest Service, which is in the Department of Agriculture. The Forest Service's role is strictly advisory, and even its advisory role is under assault by the oil and gas industry.

Second, both the Forest Service and the Department of Interior appear unwilling to assert their authority to deny development of a lease in order to protect the environment. On this issue, the federal agencies have been playing both sides of the fence. Once a lease is issued and a drilling permit is sought, the federal government argues that it cannot deny permission because the lease conveyed a right to develop.* However, prior to leasing, the government frequently argues that leasing is a mere paper transaction and that permission to develop can be denied later in the process. The courts have yet to determine which stance is legally binding. In the meantime, the federal government has refused to deny an APD anywhere in the Greater Yellowstone area for environmental reasons. And while the government plays both sides of the fence, it continues its pattern of promiscuous leasing of environmentally sensitive lands in the Greater Yellowstone area.

* *The acting regional solicitor for the Rocky Mountain Region of the Department of the Interior, Lowell Madsen, wrote a memorandum dated Oct. 10, 1980: "No precedent exists for denial of an application for a permit to drill under the onshore oil and gas lease based on environmental protection considerations. Additionally, such denial would have constitutional implications concerning the taking of property rights and payment of just compensation provisions of the Fifth Amendment."*

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# II. The Environmental Impacts of Oil and Gas Exploration and Development

## Seismic Exploration

Prior to undertaking exploratory drilling operations on land overlying possible petroleum reserves, oil companies undertake seismic exploration to define the underlying geological structures. Seismic testing usually consists of generating sound waves in the ground, using explosives or mechanical means, and analyzing the returning echoes for clues to buried geological formations.

When a profile of the subsurface geology is constructed, certain structures may be found that could contain oil or gas. Seismic tests cannot confirm the presence of a hydrocarbon reserve, and exploratory drilling must be done to further investigate promising structures.

Seismic tests using mechanical means involve large "thumper trucks," which are designed to raise and drop a metal slab weighing several tons onto the ground to generate sound waves. This requires an established road system, or else gentle, open terrain that the large vehicles can maneuver across without benefit of roads. Since most of the land in the Greater Yellowstone area is densely wooded, roadless, mountain country, explosives must be used.

Seismic tests using explosives are "shot" in lines laid out in a grid pattern. In roadless country, crews are frequently flown in by helicopter. They set up a seismic line several miles long with explosives placed at ground level or slightly above at intervals of 25 to several hundred feet. Near the line of explosives are placed a series of devices called geophones, which pick up the underground echoes of the exploding charges. When the seismic line is shot, hundreds of pounds of explosives are detonated simultaneously and the underground echoes recorded. Lines are frequently shot in parallel, with two lines located one or two miles apart, a method that produces data of a higher quality.

A good seismic crew can set up and shoot several lines a day and are frequently based at a backcountry location with a heliport.

Since data gathered by seismic testing is proprietary, energy companies do not share the information with each other or with the public land managing agency. Consequently, each company in an area shoots its own seismic lines, and often several crews will be working in the same area at the same time.

Repetitive seismic testing introduces an enormous amount of human activity into remote areas. Over a two-year period in 1982-83, more than 4,000 miles of seismic lines were shot on the Bridger-Teton National Forest alone. During the last half of the decade, all the national forests surrounding Yellowstone have seen a major increase in the amount of seismic work.

Each individual detonation of several pounds of explosive does some temporary damage to the ground and the surrounding vegetation, but these scars can be healed by natural processes over one or two growing seasons. A greater danger to the environment lies in the possibility of the explosives causing wildfires, which can be difficult to extinguish in backcountry areas. The Forest Service has responded to by this limiting seismic work during periods of high fire danger, but accidental ignitions still occur every summer throughout the Rockies.

The impact of seismic testing on sensitive wildlife populations is also a cause for serious concern. Such impacts are difficult to quantify since few field studies have been conducted. Wildlife biologists believe that although impacts to habitat may be minor, intense seismic activity can have significant adverse impacts on sensitive species. Elk, for example, have been known to leave their summer ranges in valleys where seismic activity is being undertaken. With several seismic crews working in a single area, elk herds can be driven back and forth through the forest, trying to escape the explosions and helicopters.

Similar concerns for bald eagles have prompted biologists with the Shoshone National Forest to suggest banning seismic activities along certain river corridors, such as the South Fork of the Shoshone River, during nesting season, and to recommend restrictions on seismic operations in other parts of the forest.

Grizzly bears are generally intolerant of human activity of any kind. The continual noise of explosions, intense helicopter activity, and the increased human activity involved with shooting seismic lines have the potential to permanently remove grizzlies from an area.

Concussion from seismic testing can also disturb the grizzly within its den. Such disturbances could cause a bear to leave its den during the winter months when food sources are scarce, and it would be difficult for the bear to locate or dig another. It is estimated that any seismic blast within a two-mile radius of a den could cause a grizzly to leave the den area, and the removal of the immediate disturbance is no guarantee that the bear will return.

If wildlife impacts from seismic exploration have been poorly studied, possible impacts to outdoor recreationists have not even been acknowledged by the Forest Service. Hikers, horsepackers, and fishermen, like elk, are displaced from backcountry areas where seismic testing is occurring, and horseback riders have been injured after being thrown from their mounts due to nearby seismic blasts.

Even a dozen miles into the core of the

vast Washakie Wilderness, hikers can hear the nearly continuous rumble of seismic testing on the area's periphery. Someone who uses their annual two-week vacation to drive across the country to visit Yellowstone and Grand Teton national parks may find that continuous seismic blasting severely detracts from the wilderness experience they were expecting. When one considers that a quarter of million people may visit Grand Teton Park during a single week in the summer months, this particular impact of seismic exploration takes on a new significance.

During the last several years, considerable seismic testing has taken place not only near Grand Teton's eastern and southern boundaries, but adjacent to the east, northeast, and west entrances to Yellowstone as well.

## Exploratory Drilling

Since seismic exploration only delineates underlying geological structures and cannot confirm the presence of hydrocarbons, exploratory drilling must be done in order to conclusively find oil and gas. Here in mountainous country surrounding Yellowstone, the geological formations that may contain oil or gas are deeply buried, often as far as 10,000 to 15,000 feet below the surface. This fact means that exploratory drilling requires more time and larger drilling equipment than in many other onshore areas.

An exploratory drilling operation has several requirements. A level area of 1 to 4 acres is needed for the rig's drillpad, crew trailers, and vehicle parking. A large plastic-lined pit called the reserve pit or sump pond must be constructed to hold rock chips from the drill hole, used drilling muds, and toxic brines that may be encountered during the drilling. A source of fresh water capable of supplying between 5,000 to 15,000 gallons per day is required for mixing drilling mud, cleaning equipment, and cooling engines.

A crew of several dozen workers keeps the operation going around the clock, 24 hours a day, until the desired depth is reached. Depending on what problems may be encountered with the operation, a deep well may take between 3 to 18 months to complete. During this time the operation must be serviced with supplies, replacement parts, and fresh crew members.

All this requires high standard road access to the drill site. To date, only one exploratory drilling operation in the Yellowstone area – the North Fork Well on the Shoshone Forest – has been exclusively serviced by helicopter. Oil companies are reluctant, for good reason, to use helicopter access, since this can increase the cost of an exploration well by a factor of ten. Regular exploratory wells cost anywhere from 1 to 5 million dollars to complete, and helicopter access can force the total cost as high as 15 to 20 million dollars. If the well produces, a road system is necessary in any case, along with a pipelines to bring the petroleum products to market.

TABLE 2.

### Applications for Permits to Drill (APDs) in the National Forests Around Yellowstone National Park

| National Forest | Total Number of APDs Granted | APDs Granted in last 15 years (post-NEPA) | Number of APDs Pending or Anticipated | Number of Producing Wells |
|---|---|---|---|---|
| Beaverhead | 0 | 0 | 1 | 0 |
| Bridger-Teton | 151 | 88 | several | 4 |
| Custer | 6 | 6 | several | 0 |
| Gallatin | 6 | 4 | several | 0 |
| Shoshone | 33 | 22 | several | 0 |
| Targhee | 6 | 3 | several | 0 |
| TOTALS | 202 | 124 | several | 4 |

There have been almost 200 exploratory wells drilled on the national forests surrounding Yellowstone (Table 2), the majority of them requiring some new road construction. The new roads have frequently come at the cost of losing formerly roadless country and the security of the wildlife habitat within it.

Prior to the second Roadless Area Review and Evaluation process in 1979 (RARE II), it had been the policy of the Bridger-Teton National Forest to lease large roadless tracts without any concern for the possibility of subsequent roading and drilling. During RARE II, Jim Conner, a planner with the Bridger-Teton Forest, minimized the potential conflict between oil development and roadless country:

> "We don't have much data yet about where the leases are and whether they will present a problem for the roadless areas. There's not going to be as much of a conflict as people think."

The roadless lands that Conner referred to had been under lease for as long as two decades, yet the Forest Service had not evaluated possible conflicts until the drilling boom of the late 1970s ran head on into the RARE II process. More often than not, roadless lands came out the loser. Portions of such formerly large roadless areas as the 270,000-acre Grayback Ridge area in the northern Wyoming Range, the 260,000-acre Salt River Range, the 180,000-acre Commissary Ridge area, and the 90,000-acre Mt. Leidy Highlands, have been roaded for oil and gas exploration since 1978. Drilling has also occurred or is planned in the Gros Ventre Wilderness and the Palisades Further Planning Area/Wilderness Study Area.

Roads for exploratory drilling are being planned or are already under construction on wild lands adjacent to the Washakie Wilderness on the Shoshone National Forest and in wild country adjacent to the Absaroka-Beartooth Wilderness in Montana.

Wyoming Game & Fish Department officials have had many problems with the exploration roads in the Bridger-Teton Forest. When an environmental assessment on an APD is prepared, the Forest Service asks for an evaluation of possible impacts to wildlife from the drilling activity from the department. A frequent complaint of the wildlife biologists is that the denial of the drilling request is never considered; only mitigation strategies are discussed.

A wildlife mitigation plan involves such things as the consideration of alternate routes for the well access road in order to minimize impacts on wildlife winter and summer ranges and to avoid road construction on erosive soils. The timing of the drilling operation is also examined in an attempt to avoid conflicting with wildlife migration routes. Lastly, rehabilitation requirements for the drill site and access road are considered.

According to biologists, these mitigation plans often come to naught, since after drilling one unsuccessful well, the oil company, armed with new geological information, will need to drill another well in the same area. Also, limits on periods for drilling have been routinely waived because it costs too much to cease drilling once it has begun.

In a recent case, the Wyoming Game & Fish Department and the Forest Service agreed to a drilling permit deadline of November 30, 1985, for an exploratory well near Dick Creek on the Shoshone National Forest. The well was in crucial, preferred winter range for over 300 elk, and the deadline was designed to protect the herd. The company, Aurora Minerals, did not start drilling until three days before the deadline and then was given an extension by the Forest Service. The Wyoming Game & Fish Department called it "a reasonable stipulation (that) has been ignored."

What began as a one-time entry into roadless wildlife habitat has become repeated entry into a now extensively roaded drainage, with between five to ten well sites. This has happened along Spread, Nation, Leidy, and Horsetail creeks in the Mt. Leidy Highlands, just east of Grand Teton National Park, in the upper Green River country between the Gros Ventre and Bridger wilderness areas, and in formerly roadless valleys in the Wyoming and Salt River ranges. After drilling is completed, it is difficult to permanently close access roads to the public. A tradition of motorized use becomes established that is very hard to discourage. Hunters and off-road vehicle enthusiasts protest the closure, and frequently ignore and go around locked gates or other barriers. Continued motorized use can frustrate revegetation of both the well site and the access road. As one Forest Service employee stated in 1977, in reference to the Bridger-Teton National Forest, "the public isn't used to any road controls in this forest."

Oil and gas access roads into unroaded drainages have also made new timber sales possible. Although Bridger-Teton officials claim that this has not occurred in the last four or five years, it has happened in the past, with the timber sales following drilling in the Fall Creek drainage southwest of Jackson in the Palisades.

Increased sedimentation in pristine mountain streams due to roading is becoming more common as increased drilling takes place in roadless country. But a potentially more serious problem is the pollution of streams by chemicals used in the drilling process and toxic brines brought up from deeply buried formations.

In 1972, an uncontrolled salt water flow from a drilling operation contaminated Pine Grove Creek near the southern portion of the Bridger-Teton National Forest. The sudden influx of brine killed an estimated 1,100 cutthroat trout. In 1978, a severe thunderstorm filled a reserve pit containing toxic drilling chemicals, causing it to burst and empty into this same creek. Streambed habitat for fish was severely damaged for two or three miles downstream. Fisheries biologists hope that sump pits will be constructed more carefully to avoid such storm failures.

Water supply is also a problem for drilling operations. Drillers in some drier areas have been forced to build small dams on streams and construct ponds in order to assure sufficient water for operation.

The Greater Yellowstone area includes some of the best blue-ribbon trout fisheries in the Lower 48 States. The Madison, Gallatin, Yellowstone, Shoshone, Green, Snake, Henrys Fork Rivers, and host of smaller streams, attract thousands of anglers from throughout the world to their quiet pools and sparkling riffles. A recreation study done in Gallatin County, Montana, on the northwest boundary of Yellowstone Park, found that trout fishing brought more money into the local economy than logging. A sump pit failure at or near the headwaters of any of these streams would affect not only the fish but the local economy as well.

## Full Field Development

As oil and gas development activities progress, the length of time on their impacts the environment increases. The small impact of a few well-run seismic lines may be healed by natural processes in one or two growing seasons. The revegetation of an exploratory well site and access road can take as long as ten years ... if continued motorized use is controlled. If the road is left open, the environmental impact becomes more permanent. With a fully developed oil or natural gas field, the industrial support facilities remain for the life of the field, which can be between 40 to 100 years. After abandonment of the field, according to wildlife biologists, the reestablishment of some plant communities vital to big game can take as long as 50 years. For all practical purposes, the impact of field development lasts a century, throughout which time a natural landscape has been turned into an industrial one. Of the almost 200 exploratory wells drilled on the national forests adjacent to Yellowstone, only 5 wells have discovered commercial quantities of hydrocarbons, chiefly natural gas. One well drilled in the 1970s in Line Creek Canyon on the Custer National Forest discovered natural gas; but it was capped and sealed, and has not been developed. New proposals announced in late 1985 to drill near the same area may indicate that the development of a gas field is not far off. The other four producing wells are found on the southern reaches of

Philip Hocker

*A typical drilling operation on the Bridger-Teton National Forest near Kilgore Creek. The exploratory well is a temporary disturbance, but it can lead to a permanent industrialization of forest lands if a field is discovered and developed.*

the Bridger-Teton National Forest, west and northwest of Big Piney, Wyoming. Two of the producing wells are part of the huge Riley Ridge Gas Field, which is shared between national forest and BLM lands. During 1985, ten other wells associated with the development of Riley Ridge were being drilled on national forest lands.

Riley Ridge lies 90 miles south of the town of Jackson, but another potentially producing well is closer to the parks. In 1981, Exxon discovered natural gas in the South Fork of Spread Creek (part of the Mt. Leidy Highlands) just 15 miles east of Grand Teton National Park. More drilling in the area is proposed to more fully define the extent of the resource.

After an exploratory well has been successful, several more wells are needed to fully define the extent of the underground hydrocarbon reservoir. Once the extent of the reservoir is known, production wells can be drilled. Placement of the production wells is critical in order to obtain optimal production. Therefore, many more new roads and drill sites are necessary. Following placement of the production wells, a pipeline gathering system is constructed, and the petroleum product is brought to a central location and tied into a major trunk pipeline. With some forms of natural gas, a processing facility near the well field is needed to treat the gas before it is pumped into a trunk pipeline.

Riley Ridge, one of the largest gas fields of its type in the nation, exhibits all of the features found with full field development. Development plans include drilling 238 production wells in a 159,928-acre well field. The production wells will be connected by gathering pipelines and 298 miles of access road; 12,852-acres of land will be disturbed during construction, although some of the area will be immediately reclaimed, following the burial of the gathering pipeline system.

Because the Riley Ridge gas is "sour," containing large amounts of hydrogen sulfide ($H_2S$), four huge gas treatment plants will be needed, with the capability of processing 2.8 billion cubic feet of natural gas per day and producing 576 million cubic feet of methane per day. To supply power to the treatment plants, 98 miles of new electric powerlines will be constructed. Since elemental sulfur is a valuable commercial product, a 7-mile railroad spur from a major rail line will be built, along with a special 54-mile-long, electrically heated pipeline to transport the gas to market. Within the last year, carbon dioxide ($CO_2$) has been discovered in the field, and it too has been found to have commercial value. Large amounts of carbon dioxide are necessary for repressurizing old gas and oil fields in a process called tertiary recovery. Major $CO_2$ pipelines are now under construction at Riley Ridge. At its peak, the construction work force for the project will reach as many as 6,500 persons. After the completion of the industrial facilities, the number of jobs will decrease to about 2,000. Well field development activities will take until 1993. Field production is estimated to last for 40 years, until 2023. Abandonment of the field and cleanup of the facilities is expected to last until 2029.

Cary Hull

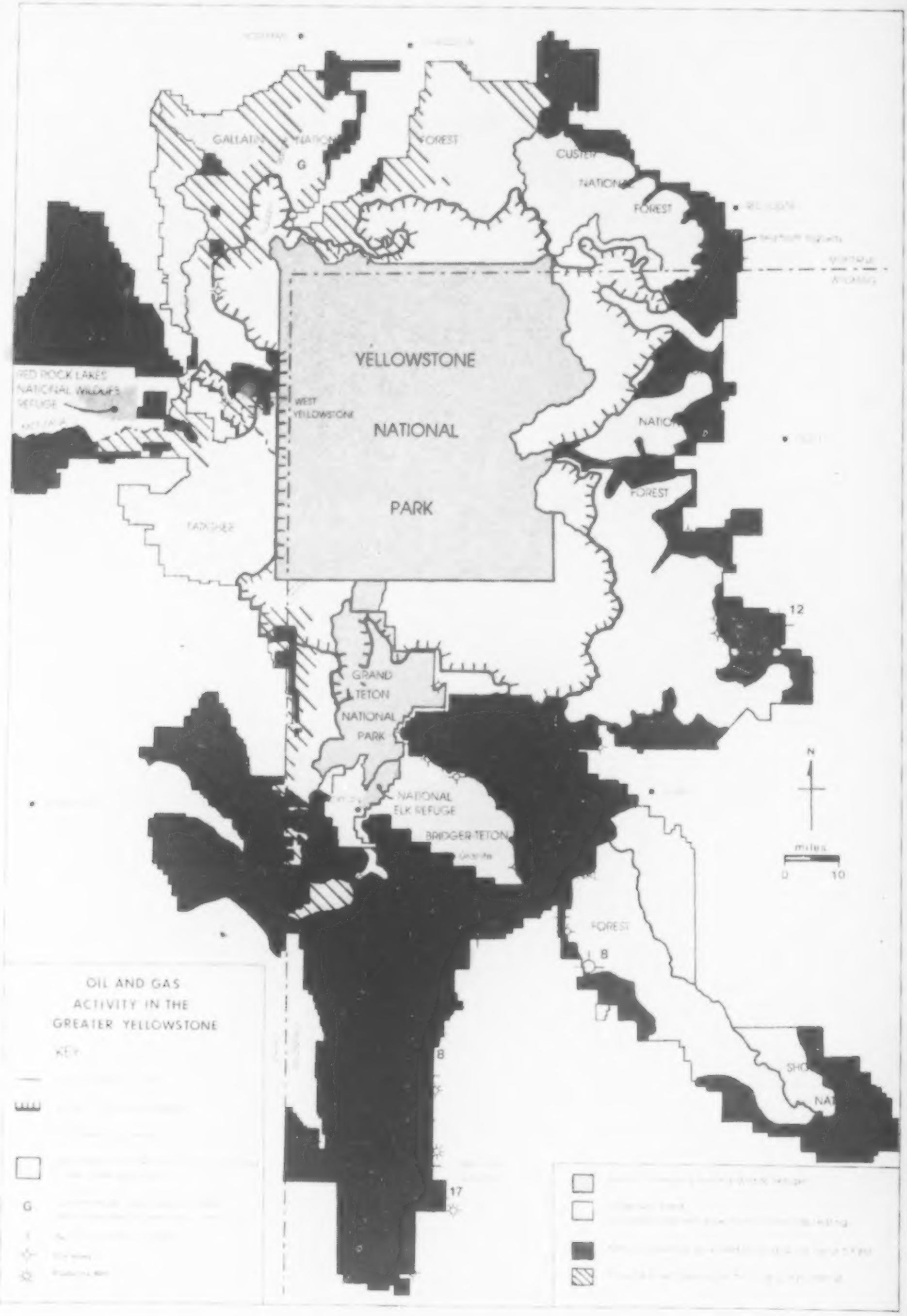
*The world-famous Yellowstone-Grand Teton elk herds are threatened by oil and gas development around the parks. As roads and drill sites proliferate in the once-wild national forests surrounding the parks the elk are forced to abandon their former home ranges.*

The first shallow exploratory wells were drilled in the Riley Ridge area in 1949, but serious drilling for deep gas did not get under way until the late 1970s. If the companies' predictions are accurate concerning the projected lifetime of the field, by the time all field work ceases, industrial activity in the area will have spanned 80 years. With a project of this magnitude, it is impossible to prevent all impacts to wildlife. The Wyoming Game & Fish Department became involved in the early planning stages of the Riley Ridge project in an attempt to mitigate the worst of the damage. They soon found that it was extremely difficult to prepare specific wildlife mitigation plans when planned industrial activity at the project was constantly changing.

In order to minimize permanent damage to wildlife, specialists tried to limit unnecessary expansion of the road network; 10,880-acres of critical wildlife ranges for elk, mule deer, moose, pronghorn antelope, and prairie dogs are expected to be disturbed by construction of facilities. The EIS on the project estimated that disturbances to critical wildlife ranges will result in population reductions of 63 elk, 174 deer, 6 moose, and 28 pronghorn during well field construction and operation. The actual wildlife habitat affected will go far beyond the 10,000-acre figure, however, due to increased human activity, including poaching. One portion of the well field will include one well drilled on every section (640 acres) for 64 square miles, all of which will be connected by a web of access roads and gathering pipelines. Wyoming Game & Fish officials have found it hard to convince oil field operators to drive the long way around between adjacent well sites, rather than grading a road directly between each drill pad, in order to protect wild animals in the area. A Game & Fish employee complained, "with this much money involved, the oil companies can build roads anywhere." Wyoming Game & Fish has been only slightly successful in limiting road construction and has been forced to feed elk during the winter in order to stabilize their population. Even this operation was partially disrupted when Game & Fish had to remove a hay barn used to store winter feed for elk to make way for a new drill pad.

During the winter months, animals such as elk live on very narrow energy budgets. If the animals are harassed or disturbed by human activity, they will move from their feeding areas and may not have the physical reserves to survive the winter. Game & Fish biologists originally sought to limit human activity along the roadways throughout the well field by helping design operating plans so they didn't conflict with big game feeding times. This mitigation approach has failed, with biologists claiming that companies continually change operating plans without consulting them.

Aside from the direct loss of wildlife due to habitat disturbance, biologists estimate that 100 to 1,000 game animals are lost each year to poaching and a similar number in vehicle-animal collisions.



OIL AND GAS ACTIVITY IN THE GREATER YELLOWSTONE

KEY

GALLATIN
NATION
FOREST
G
CUSTER
NATION
FOREST
YELLOWSTONE
NATIONAL
PARK
WEST YELLOWSTONE
RED ROCK LAKES NATIONAL WILDLIFE REFUGE
TARGHEE
NATIO
FOREST
12
GRAND TETON NATIONAL PARK
NATIONAL ELK REFUGE
BRIDGER-TETON
FOREST
8
8
17
SHO
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miles
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Philip Hocker

*Full field development involves a maze of roads, wells, power lines and other facilities that transforms wild country into an industrial scene. This producing field is in Southwestern Wyoming near LaBarge.*

The Riley Ridge project is far south of any occupied grizzly habitat, and no exploratory wells have yet been drilled in Situation I areas near Yellowstone (Situation I habitat is under lease on the Bridger-Teton and is open for leasing on the Gallatin and Targhee national forests). But full gas field development has been shown to harm bear populations in habitat adjacent to Waterton National Park in Alberta.

Two different studies have shown a pronounced decline in the number of grizzlies following oil and gas activity in the Waterton area. The major problem is poachers who follow the oil and gas access roads deep into formerly-roadless valleys. Canadian wildlife experts believe that the legal hunting season for bears in Alberta will have to be reduced to make up for the illegal kills. Full field development activities also have impacts on air quality. Hydrogen sulfide is a very toxic gas, presenting unique problems when found in quantity with natural gas. Special precautions must be taken at the well site to prevent any accidental gas release. In 1981, a blowout occurred on a well being drilled by American Quasar, and a small herd of antelope were killed by the fumes.

Less dramatic but equally serious is the well fields' possible contribution to acid rain. Significant amounts of sulfur dioxide and nitrogen oxides are released from the Riley Ridge facilities. These gases are known to be associated with acid rain. Lakes and streams in granitic mountain ranges, such as the Wind Rivers 40 miles downwind of the project, are particularly susceptible to acidification. Aquatic life in lakes can be seriously harmed by "acid shock," which occurs when acid deposited in the winters' snows rapidly melts in the springtime, suddenly increasing the lakes' acid levels.

A small decrease in pH (increase in acidification) is predicted for some Wind River lakes as a result of the Riley Ridge Project, but BLM and Forest Service biologists felt that this impact would not be enough to cause immediate harm to fish populations. More monitoring of water quality in the Wind Rivers will be necessary to confirm or deny this prediction.

The breadth of the impacts of the Riley Ridge Project is best summarized by this revealing quote from the project EIS:

> "The project as proposed would substantially alter the visual character of much of the project area and contribute to a continued progression from a predominantly natural landscape to one that is man-dominated."

The national forests of the Greater Yellowstone region contain some of the most sublime and awesome natural landscapes in the nation. The Forest Service assessments of oil and gas leasing have never examined which of these landscapes are suitable for conversion into "man-dominated" scenes.

Despite the impacts identified in the Riley Ridge EIS, the project is going ahead full bore. Part of the reason is revealed with refreshing honesty by the authors of the EIS:

> "The first premise of federal oil and gas leases, under the Minerals Leasing Act of 1920 as amended, is that the oil and gas lease between the U.S. Government (lessor) and lessee constitutes a contractual agreement with given rights and restrictions . . . A review of leases within the project reveals that site-specific APDs can be denied on environmental grounds, but drilling must be allowed at some location on the lease, with reasonable mitigation measures. In these particular instances, a blanket denial of APDs would constitute a cancellation of the leases, and therefore a breach of contract, not within the powers of the Secretary of Interior."

In the EIS scoping process for the Riley Ridge Project, Bob Doak of the Sweetwater County Wildlife Association commented on the continuous energy development activities in his area, "For a lot of years we have been mitigating for wildlife and habitat, and each time wildlife comes out the loser. Kind of like being nibbled to death by ducks. No big bites, but in the end, you lose the ball game."

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# III. Forest Plans and the Leasing Process

## Management Shortcomings

In 1976, Congress passed the National Forest Management Act (NFMA), which instructed the Forest Service to begin preparing comprehensive plans for each forest. Two major purposes of NFMA were to fully integrate the direction of all multiple-use activities on a forest into one management document, and, by producing such a plan, to make the management process of a forest more open to public review and comment.

In the first draft plans for the forests surrounding Yellowstone, released during 1985 and early 1986, oil and gas leasing and minerals management is still the most poorly managed and integrated of all forest uses. While a few forests have tried to remedy the previous shortcomings of their environmental assessments dealing with oil and gas, other forests have made little or no effort to revamp the management of the leasing process.

Such other forest uses as timber development are dealt with in a standard manner with a relatively high level of detail in nearly all forest plans throughout the National Forest System. In contrast, the only consistency apparent in the manner in which oil and gas leasing and management is dealt with is a depressing and uniform inadequacy.

The Forest Service argues that the forest planning process gives general direction and that the details and site-specific information will be developed at a later date. The actual use of the Shoshone plan since its approval demonstrates that this is not the case. On April 14, 1986, the first day of the plan's implementation, approximately 70 oil and gas leases were recommended by the Shoshone National Forest to be issued by BLM. There was no additional documented environmental analysis or environmental assessment performed regarding the impacts on environmental values that might result from development of these leases.

For example, the report on leases WX33541, WX52138, and WX68896, sent to the Forest Service's regional office from the Shoshone National Forest on April 14, 1986, recommends a finding of no significant impact "tiered to the Shoshone National Forest Land and Resource Management Plan." No other documented environmental study has been done.

The plan, in contrast, states that a "site-specific interdisciplinary environmental analysis will be initiated..." on leasing recommendations. The Forest has now demonstrated that "analysis" means nothing more that filling out a recommendation form. Leasing decisions are being made through the forest planning process, in effectively final form.

In this portion of the report we will examine how the six draft forest plans handle different aspects of the leasing and management of oil and gas. (Table 3 has a comparison of the oil and gas sections of the draft forest plans.)

**TABLE 3.**

### Summary of Oil and Gas Leasing and Management Sections in the Draft Forest Plans

| National Forest | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Beaverhead** | N | — | — | N | N | N | N | N | Y | N |
| **Gallatin** | N | Y | Y | N | N | N | N | N | Y | N |
| **Custer** | N | — | — | N | N | N | N | N | Y | Y |
| **Shoshone** | N | N | Y | N | N | Y | N | N | Y | N |
| **Bridger-Teton** | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| **Targhee** | N | Y | Y | N | N | N | Y | N | N | N |

Y = YES. Draft plan contains that information or takes that action.
N = NO. Draft plan does not contain that information or does not take that action.
— = Item does not apply to this forest.

1. Removes some environmentally critical lands (other than grizzly bear habitat) from leasing.
2. Leases grizzly bear Situation I habitat.
3. Leases lands directly adjacent to Yellowstone or Grand Teton National Parks.
4. Evaluates possible impacts to parks from oil and gas activities in the forest.
5. Evaluates the cumulative effects of oil and gas exploration and development activities in the forest.
6. Contains a clear summary of oil and gas leasing statistics for the forest.
7. Contains a map of existing leases in the forest.
8. Contains a map of areas open to oil and gas leasing in the forest.
9. Shows how much land is open to oil and gas leasing under each management alternative.
10. Has standards or guidelines for management of oil and gas activity.

## Continued Leasing of Critical Areas

Only two of the plans for the forests in the Greater Yellowstone area remove any lands outside of designated wilderness or congressionally designated wilderness study areas from oil and gas leasing.

The managers of the other four forests believe that oil and gas activity is suitable on all forest lands that Congress has not specifically withdrawn from mineral leasing. It is interesting to compare this management direction with that of the timber resources on the forests.

Few forest plans set a management direction for timber that encourages timber companies to log every acre outside of protected wilderness. Some unproductive forest acres are withdrawn from the timber base, other acreage is set aside to be primarily managed for wildlife or for roadless recreation opportunities. Still other forest lands are left alone at present, but may be logged several decades from now.

In contrast to this complex approach to timber management, most national forests have an overly simplistic approach to minerals management: oil and gas activity will be permitted on all forest lands except those lands that Congress officially withdraws from leasing. As a result, many environmentally critical areas in the Yellowstone region continue to be leased and exposed to the risk of full-scale energy development.

## Leasing of Prime Grizzly Bear Habitat

The grizzly bear is a threatened species under the terms of the Endangered Species Act, and all federal agencies are supposed to refrain from actions that would jeopardize the bear's continued existence. Despite the clear evidence that oil and gas development, and even exploration, can damage grizzly habitat, the national forests near Yellowstone have developed no consistent approach to leasing for oil and gas in prime grizzly habitat.

Two forests, the Beaverhead and the Custer, do not have any Situation I grizzly habitat (presently used and considered essential) outside of designated wilderness, and are not faced with the decision to lease. In the other four, the management prescriptions vary wildly.

In the Shoshone, the forest plan upholds an earlier decision not to lease most Situation I habitat outside of wilderness (originally decided in an environmental assessment in 1982). Following the Shoshone's lead, the early drafts of the Bridger-Teton plan allow for no further leasing in Situation I habitat. However, on the Bridger-Teton, the agencies are faced with the problem of managing already-existing leases. Some of these leases have had exploratory drilling in the past and are presently attracting new interest.

The Gallatin forest plan allows widespread leasing in Situation I habitat and intends to rely extensively on so-called "no surface occupancy" stipulations (NSOs) to protect identified areas of high grizzly bear activity. The Targhee Forest plan has had no lease applications for Situation I habitat as yet, but will consider each application on a case-by-case basis.

The conflicting approaches to mineral activity in essential grizzly habitat is a prime example of the confused nature of minerals management on the forests near Yellowstone. It becomes even more dramatic if you consider the fact that the coordination of grizzly management activities among the forests and between the forests and the parks is frequently cited by the Forest Service as an excellent example of integrated ecosystem management.

Aside from grizzly bear habitat and small areas around campgrounds and ranger stations, only one forest intends not to lease other sensitive lands in its forest plan. The Bridger-Teton, after years of public controversy concerning oil and gas activities surrounding the town of Jackson, Wyoming, will probably recommend no leasing on about 40,000 acres once the forest plan is issued. This move is intended to protect wildlife habitat, heavily used recreation corridors, and the scenery around Jackson.

It would be an understatement to say that this decision is not solely the result of enlightened forest management. There has been more than half a decade of intense controversy involving the impacts of increased oil and gas activity on the predominant business of the Jackson area, tourism. On other forests, where the public pressure has been less intense, the leasing of sensitive areas continues, including lands directly adjacent to the parks.

## Leasing of Lands Adjacent to the Parks

Farsighted action by the U.S. Congress has protected much of the forest land abutting Yellowstone and Grand Teton parks as wilderness. However, on non-wilderness lands adjacent to the parks, the inconsistency of the forest plans concerning leasing activities is just as glaring as it is in the case of grizzly habitat.

On the eastern edge of Jackson Hole, the Bridger-Teton Forest is proposing no-surface occupancy on a 15-mile-long, 1/2-mile-wide-strip of land adjacent to Grand Teton National Park. This attempt to minimize damage to the park's scenic resources may not be successful, since drilling rigs located 1/2 mile east of the park boundary would also be several hundred feet uphill from the park, actually increasing the visual impact on park visitors. With exploratory drilling activity on the increase in this, the Mt. Leidy Highlands area, the future may bring oil derricks to Grand Teton's skyline.

Although the Shoshone National Forest has been in the lead in protecting grizzly bear habitat, the Shoshone Forest plan still permits extensive leasing along the North Fork of the Shoshone River, up to the eastern entrance to Yellowstone. No evaluation of the possible effects of oil and gas activity on the park's wildlife, air quality, or recreational values are examined in the plan.

In the late 1970s, exploratory drilling proposals for geothermal energy resources in the Targhee National Forest's Island Park area caused a national controversy.

The Targhee plan wisely refuses to grant geothermal leases there until it can be proven that there will be no affect on Yellowstone's geysers. Oil and gas lease applications in the Island Park area are also on hold until their possible impact on the geothermal resources of the park can be ascertained. A small portion of the Island Park Known Geothermal Area (KGRA) extends northward on the Gallatin National Forest almost to the town of West Yellowstone. Although the Gallatin Forest has not leased this portion of the KGRA, the Gallatin continues to lease lands adjacent to the park in the Hebgen Lake area and proposes in its forest plan to open the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area to extensive leasing.

Four months before the draft Gallatin Forest Plan was released, the federal district court in Butte, Montana, ruled that the Gallatin's environmental assessment on oil and gas leasing violated both the National Environmental Policy Act and the Endangered Species Act. Specifically, the court found that the Forest Service failed to evaluate the cumulative impacts of oil and gas development beyond the leasing stage. The biological assessment concerning affects on the grizzly bear required by the Endangered Species Act did not examine post-leasing impacts and was also found to be inadequate. The draft Gallatin plan fails to address the issues the court raised, and instead proposes leasing 131,900 acres (85%) of the 155,000-acre Hyalite-Porcupine-Buffalo Horn Wilderness Study Area for oil and gas.

The Hyalite-Porcupine-Buffalo Horn area is a congressionally designated wilderness study area established by the 1977 Montana Wilderness Study Act in the northern half of the Gallatin Range on the drainage divide between the Yellowstone and Gallatin rivers. The southern half of the Gallatin Range lies within Yellowstone National Park, abutting the wilderness study area for 10 miles. Only an act of Congress can release the area from its wilderness study status.

If the draft Gallatin plan recommendations are accepted by Congress, leasing will proceed for another 10 miles adjacent to the park's northwestern boundary, including 48,600 acres of occupied grizzly bear habitat.

The Gallatin's willingness to lease the wilderness study area with so little consideration to the possible environmental impacts is all the more disturbing when the opinions of the U.S. Geological Survey (USGS) are taken into account.

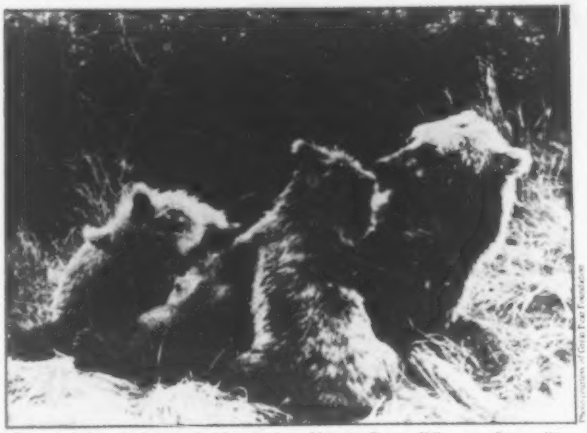


Photo courtesy of Great Bear Foundation

*The grizzly bear is threatened with extinction within the Greater Yellowstone Region. When humans and bears compete for the same land the bear inevitably loses. Yet in most national forests surrounding Yellowstone the Forest Service is recommending leasing of critical grizzly bear habitat.*

During the RARE II process, the USGS gave the Gallatin Range a low to moderately low rating for oil and gas potential. No forest lands in the area rated in the top two categories for hydrocarbon potential (high or very high).

Another USGS study of the Gallatin Range, released in 1980, had similar findings:

"Oil and gas resources are unlikely because possible productive structures are small and deeply eroded. The roadless area has little promise for the occurrence of other mineral or energy resources."

The report also noted:

"The Eocene volcanic rocks that make up so much of the area would be excellent reservoirs for geothermal fluids."

Although not within any known geothermal resource area, the National Park Service now suspects that the Gallatin Range may be the primary groundwater recharge area for several of the northern Yellowstone geyser basins. Any drilling in this region could have a deleterious effect on the park's geothermal resources, yet the forest plan does not examine possible impacts on the park. As has too often been the case with previous environmental assessments, the forest plan barely acknowledges the existence of Yellowstone Park and has no evaluation of the consequences of suggested leasing actions on its environment.

The Gallatin, of all the national forests surrounding Yellowstone, permits the most amount of leasing directly adjacent to the park's boundary. From the towns of Jardine and Gardiner at Yellowstone's north entrance around the western side of the park to the town West Yellowstone, almost 30 miles of forest lands on the park boundary will be open for leasing once the final forest plan is approved.

The actions of the Gallatin National Forest show the oil and gas leasing process at its worst: continued leasing of lands with low energy potential and high environmental sensitivity, with no consideration of the impacts of development.

## Forest Planning and Public Information

One of the primary goals of the forest planning process is to present a series of management options for each national forest to the public in a clear and comprehensive manner. The public then examines the pros and cons of each management alternative and can choose which management direction seems best for the forest.

The admirable goal of opening up the forest planning process to the public is made possible only when the facts concerning a natural resource are clearly presented in a forest plan. Most of the draft plans for the national forests surrounding Yellowstone fail to do this for mineral leasing and management.

In a forest plan, the possible alternative ways of managing each forest are shown on a series of maps. A citizen can examine each alternative and clearly see on the map what management direction is proposed for a particular region of the forest for such surface resources as timber, roadless and developed recreation, or wildlife. The present or proposed direction for the mineral resource is almost never shown.

Only two of the six plans for the national forests adjacent to Yellowstone – the Targhee and the Bridger-Teton – show the present extent of oil and gas leasing. The other four forest plans vaguely mention that portions of this or that ranger district or mountain range is leased for oil and gas. None of the plans show on maps how much land would be open to leasing under various management alternatives, yet each plan does precisely that to show the proposed extent of timber development.

Although the Targhee plan shows the present extent of oil and gas leasing cartographically, no numbers are included in the text to describe how many acres of land are leased. In fact, when the management alternatives for the forest are examined, only the number of acres being offered for lease which do not have any surface occupancy stipulations are listed.

The Targhee plan is not the only plan that fails to tell how much of the forest is actually leased. The Gallatin plan gives two different figures for the amount of land under lease on the forest, somewhere between 200,000 and 500,000 acres. The draft Gallatin plan goes on to describe how the chief of the Forest Service will determine whether to lease wilderness areas or not, a problem that Congress resolved more than two years ago by banning any leasing in designated wilderness.

The soon-to-be-released Bridger-Teton plan and the draft Shoshone plan are the only two out of the six forests that present data on the current leasing situation. Oil and gas leasing data in these plans is summarized clearly in tabular form.

When an interested member of the public tries to get more information on the extent of leasing, most forests are unable to provide any. This is because oil and gas leases are recorded by township and range on maps reduced for microfiche storage. By keeping records in this manner, the Forest Service makes it nearly impossible for the interested citizen, or even a forest planner, to obtain a complete picture of the oil and gas leasing situation.

Unless oil and gas leasing information is presented clearly in the same manner on maps and in tables as is the data on other forest resources, the public will continue to be left in the dark, and one of the primary intents of the forest planning process will be frustrated.

F. George

*Millions of acres of wildlife habitat around Yellowstone, including critical moose range, has been leased for oil and gas development by the federal government.*

## APPENDIX A.

# The "Greater Yellowstone" Concept

When Yellowstone National Park was established by Congress in 1872, the states of Wyoming, Montana and Idaho did not exist, nor did the science of ecology. Working from the accounts of a few exploration parties, Congress drew the park's boundaries in the shape of a giant rectangle, 54 miles wide and 62 miles high, designed mainly to enclose the major thermal features. Today we know that the park's boundaries do not even adequately enclose the geothermal resources, leaving out the Island Park Caldera to the west, the Gardiner Known Geothermal Resource Area to the north, and other less prominent geothermal features.

Ecologists now know that the biological health of the park depends in large part on the integrity of the entire Greater Yellowstone Ecosystem, which extends beyond the park's boundaries. Wildlife, including grizzly bears, elk, and bald eagles, regularly leave the sanctuary of Yellowstone and Grand Teton national parks to live out portions of their life cycles on adjacent national forest lands.

Although the concept of a Greater Yellowstone Ecosystem has received considerable attention in recent years, the history of attempts to define and protect it, and thereby protect the park itself, goes back much farther.

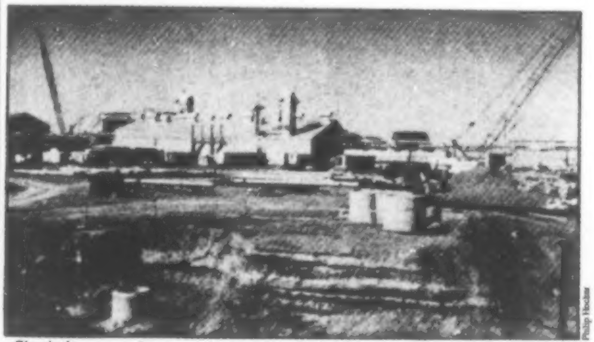
After his visit to Yellowstone in 1882, General Phil Sheridan suggested that the park be greatly expanded to the southeast, in order to more adequately protect the area's wildlife. In 1917, Secretary of the Interior Franklin Lane proposed that the park be expanded by 1,200 square miles to encompass the Teton Range and Jackson Hole. This proposal came very close to congressional approval. Although neither Sheridan or Lane were aware of the ecosystem concept, they both knew that Yellowstone's natural wonders extended far beyond the park's borders.

The modern concept of a Greater Yellowstone Ecosystem is based on several biological and geophysical factors. Rick Reese, in his book "Greater Yellowstone," defines the ecosystem based on A.W. Kuchler's and R.G. Baily's *Ecosystems of the United States*. On Kuchler and Baily's map, the Greater Yellowstone area clearly stands out as forested island of Douglas fir, western spruce, and lodgepole pine surrounded by different vegetation types, prairie grasses, and sagebrush. The central Yellowstone Ecosystem as drawn by Reese extends near Bozeman, Livingston, and Red Lodge on the north, toward Cody and Dubois on the east, beyond Jackson on the south, and toward Driggs, Ashton, and Ennis on the west. This ecosystem includes parts of six national forests, six BLM districts, two Fish & Wildlife regions and a small percentage of state and private lands. The size of this ecosystem is approximately 20,000 square miles, of which only 3,500 square miles are now contained within Yellowstone National Park.

Wildlife migration patterns for several species reinforce the ecosystem idea. The six Yellowstone elk herds summer in the high country of the park and migrate outside the park to winter ranges in the Gallatin, Shoshone, and Bridger Teton national forests, the National Elk Refuge near Jackson, and private lands. Of all the big game animals, the elk make the most wide ranging use of the ecosystem.

The grizzly bear, a threatened species in the lower 48 states, is another example. Aside from its habitat within the park, estimates show that the grizzly utilizes at least 1.7 million acres of national forest and private lands outside of the park. Thus, at least 40% of its essential habitat lies outside of Yellowstone. The Yellowstone grizzly bear population is also isolated from other populations further north along the continental divide in Montana and Canada. Left on an "island" ecosystem, the fate of the great bear depends on the biological health of Yellowstone country, and bears lost due to poaching, management actions, or natural mortality cannot be replaced by in-migration.

The third wildlife example of a greater Yellowstone ecosystem is the bald eagle. Very few of the eagles seen within Yellowstone Park during the summer months are born and fledged there, because the lakes and streams of the park are still frozen during the breeding months of March and April. Most of the eagle breeding takes place in Jackson Hole along the Snake River, on the Henrys Fork River in the Targhee National Forest, or in the Red Rock Lakes National Wildlife Refuge in Centennial Valley. Without eagle habitat in these areas, Reese says "Yellowstone's eagles probably would decline dramatically and perhaps even disappear."



Philip Hocker

*Chemical treatment plant to process natural gas for pipeline shipment to market.*

## APPENDIX B.

# How the National Forests Were Leased

In the 17 years since the passage of the National Environmental Policy Act in 1969, federal land managing agencies have steadfastly avoided evaluating the environmental impacts of onshore oil and gas leasing, making this leasing process one of the few federal actions to remain out of compliance with NEPA's environmental review requirements. At the heart of the matter is the belief by such federal agencies as the Forest Service that the act of leasing is not a major federal action effecting the environment, but a mere paper transaction between a public agency and a private business. As a result, the mineral rights for literally millions of acres of public land have passed into private hands with little or no examination of the environmental consequences.

Recent federal court decisions have challenged this belief and have asserted that the transfer of a mineral lease from public to private hands conveys certain rights for development of the mineral resource.[*] As a result, the courts have held that the land-managing agency has a responsibility to fully examine the potential environmental consequences of lease development before it commits itself, through lease issuance, to development. Finally, the courts have sustained challenges to the adequacy of pre-leasing environmental review in a number of key cases.

The Sierra Club believes that most, if not all, of the assessments covering leasing in the Greater Yellowstone area could be found to be in violation of NEPA as well.

## Fifteen Years of Evaluating Leasing in the Yellowstone Area

The environmental review documents prepared for leasing in the Yellowstone area fall into three categories based on the time they were released and the amount of information they contain.

Between 1972 and 1979, five environmental assessments covering 4.8 million acres of land on the Bridger, Teton, Targhee, Shoshone, and Custer national forests were released. These documents were essentially no more than long press releases announcing that forest lands were about to be leased.

Between 1979 and 1983, the leasing process had come under more public scrutiny, and the Forest Service responded with a few more specific environmental assessments covering leasing in particular areas.

In the third category are the leasing decisions and the mineral management guidelines contained in the first round of forest plans. In the Yellowstone region, these began with the Targhee, released in January 1985, and will be completed by the Bridger-Teton plan, soon to be released in draft form.

## The Early Environmental Assessments 1972-1979

The first category of environmental assessments covering leasing include those for the following areas:

Bridger National Forest, 1972

Targhee National Forest, 1972

Teton National Forest, 1973

Beartooth Face Planning Unit of the Custer National Forest, 1978

Rocky Mountain Region of the Forest Service, 1979

*(Table 4 has a more complete summary of leasing documents.)*

Over 2.2 million acres on the Bridger-Teton National Forest were leased in 1972 and 1973 on the basis of two brief environmental assessments. Although the Bridger-Teton Forest has seen an ever increasing amount of exploratory drilling over the past decade, re-evaluation of the basis for leasing has constantly been postponed. As a result, the management direction for leasing set by these two assessments remains in effect, even though much more information is now available both on the biological resources of the forest and the impacts of drilling in sensitive areas. The Bridger-Teton Forest refuses to release copies of these documents, explaining that they are "too out of date" and will be superseded by the forest plan. The leasing process is scheduled to be reviewed in the forest plan, which will soon be released.

The Targhee Forest released a 5-page environmental assessment (EA) on leasing in May 1972. Aside from containing no specific information on the lands being leased, the EA contains good examples of the Forest Service's reasoning on the possible impacts of oil and gas activities.

In the introduction, the Targhee Forest states "we expect no drilling to occur on the majority of the leases for which applications will be filed." This is a common view found throughout the Forest Service, which argues that since actual exploratory drilling occurs on only 10% of most federal leases in the Rocky Mountain states, there is no need to evaluate the consequences of leasing. Leasing is thus considered not to be a major federal action effecting the environment and large tracts of land can be leased without further review.

The Targhee Forest EA goes on to justify the decision to lease with several more arguments. The possible environmental impacts of exploratory drilling and production are dismissed in two pages, which is summarized thus:

"The Targhee Forest has a reputation for clean air, clean water, green forests, and good fishing. Any planned activity that will detract from these qualities must be controlled in order to minimize the detraction if possible to do so. If it is not possible, then perhaps the activity may be curtailed."

The social and economic impact of oil and gas activity is dealt with in one page on the EA, including the following paragraph:

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[*] *While the courts have held that the lease issuance stage is the time when the first commitment to resource development is made, it is not an irreversible commitment. It is possible, though difficult to change lease terms or deny development after a lease is issued.*

"A certain amount of adverse public opinion can be expected when activities are started, especially from those who will not derive a direct economic benefit from the operation. However, a joint effort by the Forest Service and the oil company concerned assuring the public that environmental values will be protected will minimize this reaction. The local government is not expected to be interested unless there is an adverse effect on the present pattern of business."

The reaction of other federal agencies is evaluated in one paragraph:

"On the federal level, the Department of the Interior, Bureau of Land Management issues the oil and gas leases. The National Park Service would also be concerned if a right-of-way would be required to cross the national Park or if drilling activity detracted from adjacent park values."

The EA analyzed alternatives and specified a course of action in the following two paragraphs:

"There is a wide range of alternatives in a complex operation connected with oil and gas leasing. These would range from a complete withdrawal of all lands from leasing to unrestricted exploration and development of the oil and gas resource.

"The best alternative would be to permit oil and gas exploration and development with restrictions determined and placed on each individual development."

The direction set by this EA governed most lands on the Targhee Forest since 1972 and remained in effect until the final Targhee Forest plan was approved last year.

This extremely cursory examination of the consequences of oil and gas leasing did not end with the Bridger-Teton and Targhee forests. In November 1979, the Rocky Mountain Region of the Forest Service, Region II, which includes the Shoshone Forest, issued a "finding of no significant impact" (sometimes referred to as a FONSI) for the leasing of 17.4 million acres of land. This action was based upon an environmental assessment just 15 pages long. The Rocky Mountain Region Oil and Gas leasing EA contains 157 pages of appendices, including 19 pages of press releases the regional office had issued on oil and gas activity and 42 pages of copies of mailing labels for every party interested in the leasing process.

The EA contains no site-specific information on any of the 17.4 million acres of land being leased, including 900,000 acres of the Shoshone National Forest. In fact, the Shoshone National Forest is mentioned only once in the entire document, on a map of the Rocky Mountain Region! Yet, the assessment was used as the basis for leasing such environmentally critical lands as those along the eastern entrance corridor to Yellowstone National Park.

As with the previously discussed assessments, the Rocky Mountain Region Oil and Gas Leasing Environmental Assessment remained in force, until the final forest plan was adopted earlier this year.

The leasing of the portion of the Custer National Forest adjacent to Yellowstone is dealt with mostly in the Beartooth Face Planning Unit Land Management Plan released in October 1978. This unit plan also dealt with small portions of the Beartooth Face on the Gallatin National Forest and on the Shoshone National Forest in Wyoming.

The Beartooth Face Unit Plan was the first leasing document issued for the Yellowstone area to actually include a map showing the location of existing leases. Unfortunately, the plan's direction for future leasing was identical to that reached for the Bridger-Teton, Targhee, and Shoshone forests: all lands outside of congressionally withdrawn wilderness areas would be open for leasing.

The Beartooth Face Unit Plan does introduce what has become another widespread problem involving leasing: over-reliance on "no-surface occupancy stipulations" (NSO stips) to protect environmentally sensitive areas. The plan approved of leasing 212,000 acres of land for exploratory drilling, with all but 49,000 acres off limits to surface occupancy.

One of the theories behind the use of such stipulations is that an oil company would not lose the opportunity to exploit the possible oil or gas resource under a lease with NSO stipulations, but instead would be able to directionally drill from an adjacent lease. In the Rocky Mountains, directional drilling laterally for distances longer than 1/2 mile is difficult because of the complexity of the underlying geological structures. As a result, much of the mineral resource under large blocks of leases with NSO stips may be physically unavailable for development.

To the Forest Service, this was the best of both worlds, protecting the surface from development while still leasing the mineral rights. Industry has argued that this practice may be illegal, because the lease holder has been granted certain rights to a mineral resource yet cannot physically reach it.

The Beartooth Face Unit Plan is also the first leasing document in the Yellowstone area to try to solicit and evaluate public input. Although the Forest Service claimed that the majority of public comments favored its preferred alternative, both the Montana Department of Fish & Game and the Wyoming Game & Fish Department protested the large amounts of land opened to oil and gas activities in their written comments.

## Oil and Gas Environmental Assessments 1979-1984

By the early 1980s, the Forest Service in the Yellowstone region began issuing longer, more involved environmental assessments covering oil and gas leasing. Included in this second category are the following:

- Beaverhead National Forest EA, 1979
- Poker Pete EA, Targhee National Forest, 1980
- Palisades EA, Targhee and Bridger-Teton National Forests, 1980
- Gallatin National Forest EA, 1981
- Hebgen Lake Ranger District EA, Gallatin National Forest, 1981
- Shoshone National Forest EA on leasing grizzly bear habitat, 1982
- Beartooth Plateau EA, Custer and Shoshone National Forests, 1983

*(Table 4 has a more complete summary of leasing documents.)*

TABLE 4.

## How the National Forests Around Yellowstone National Park Were Leased: A Summary of the Environmental Assesments Covering Oil and Gas Leasing

| National Forest | Leasing Document, Date | No. Pages Text (Appendices) | Scope | Site-Specific Info. on Lands Being Leased | Decision |
|---|---|---|---|---|---|
| **Beaverhead** | E.A. on Oil & Gas Leasing, 1979 | 50 (40) | forest-wide, 2.1 million acres | very little | Lease all lands outside wilderness, wilderness study and recommended wilderness, with appropriate stipulations |
| **Bridger-Teton** | Oil & Gas Leasing, 1972 (E.A.) | 9 | forest-wide | none | Lease all lands outside wilderness and wilderness study, with appropriate stipulations |
|  | Oil & Gas Leasing, 1973 (E.A.) | 12 | forest-wide | none | Lease all lands outside wilderness and wilderness study, with appropriate stipulations |
| **Custer** | Oil and Gas Leasing, Plateau Unit Beartooth District, April 1983 (E.A.) | 13 (6) | 33,000 acres in district | some | Lease all lands outside wilderness, with appropriate stipulations |
|  | Beartooth Face Planning Unit Land-Management Beartooth District (E.A.) | 7 (6) on leasing | 216,000 acres district | very little | Lease 212,000 acres outside wilderness, with appropriate stipulations |
| **Gallatin** | Oil and Gas Leasing, March 1981 (E.A.) | 42 (56) | forest-wide, (except Hebgen Lake District) 633,500 acres | very little | Lease all lands outside wilderness, and wilderness study and recommended wilderness, with appropriate stipulations |
|  | Oil and Gas Leasing Hebgen Lake District, March 1981 (E.A.) | 73 (46) | 49,000 acres in district (not including wilderness study, recommended wilderness, and Quake Lake Geological Area) | moderate amount | Lease all lands appropriate stipulations |
| **Shoshone** | Oil and Gas Leasing in Forest Lands in Rocky Mt. Region, Nov.1979 (E.A.) | 15 (157) | region-wide, 17.4 million acres | none | Lease all lands outside wilderness, and wilderness study and recommended wilderness, with appropriate stipulations |
|  | Forest Service (E.A.) Recommendations & Consent for Oil & Gas Lease Issuance in Occupied Grizzly Bear Habitat, Aug. 1982 | 5 (14) | Situation 1 grizzly bear habitat | some info. on grizzly bear habitat | Don't lease 82,000 acres of Situation 1 grizzly bear habitat; lease a "fringe" of 6,000 acres of Situation 1 habitat with no surface occupancy stipulations |
| **Targhee** | Oil & Gas Leasing, 1972 (E.A.) | 5 (6) | forest-wide | none | Lease all lands outside wilderness and wilderness study, with appropriate stipulations |
|  | Oil & Gas Leasing, Poker peak Area, Aug. 1980 (E.A.) | 43 (93) | 65,500 acres southwest of Palisades Reservoir | some | Lease all lands with appropriate stipulations |
|  | Oil & Gas Leasing, Palisades Further Planning Area, June 1980 (E.A.) | 49 (85) | 461,000 acres | some | Lease all lands with appropriate stipulations |

Although somewhat longer than previous oil and gas leasing environmental assessments, and including much more site-specific information on the lands being leased, all but one of these EAs reached the same conclusion: lease all lands on the forest outside of congressionally withdrawn wilderness areas, relying on stipulations on the lease to protect the environment. Although all seven of these EAs considered leasing lands in the Greater Yellowstone area, and three actually examined lands adjacent to park boundaries, only one of the documents, for the Hebgen Lake Ranger District, even mentions potential effects on the national parks.

The environmental assessment for *Proposed Oil and Gas Leasing on the Hebgen Lake Ranger District of the Gallatin National Forest* is one of the better documents from the standpoint of including basic natural resource information. But this EA is an excellent example of how an assessment can be padded with reams of information but still have major flaws that bring the legality of the leasing into question. The Forest Service chose the alternative that would lease all lands on the ranger district outside of designated wilderness, wilderness study, RARE II recommended wilderness, and the Madison River Earthquake Area. The selection of this alternative is justified thus:

"Alternative four is selected as the Forest Service preferred alternative because it best meets the criteria and maintains conditions under which man and nature can exist in productive harmony, and fulfills social and economic needs of present and future generations of Americans."

The "conditions under which man and nature can exist in productive harmony" included leasing nesting habitat for bald eagles and trumpeter swans, Situation I (essential habitat) for the endangered grizzly bear, heavily used recreation areas, and seven miles of forest land adjacent to the western boundary of Yellowstone National Park!

In leasing important wildlife habitat, the Forest Service once again relies on the use of no-surface occupancy stipulations, and another stipulation used to regulate the timing of drilling. The theory behind such timing stipulations is that to avoid impacts on wildlife, the Forest Service will simply not permit drilling during such critical periods as bald eagle nesting in the spring and early summer.

This idea seems good on paper, but fails in practice. Exploratory wells in the Northern Rockies are frequently drilled to great depths, sometimes in excess of 10,000 feet. According to some Forest Service minerals specialists, if everything goes well on a drilling operation, the 10,000-foot depth could be reached in as little as three months. But as is more often the case, when problems arise, the exploratory well can take as long as a year and a half to reach the desired depth. It is unrealistic to expect a multi-million dollar drilling operation, once underway, to cease activity for several months to accommodate bald eagle or trumpeter swan nesting. Agency mineral specialists in such heavily drilled areas as the Bridger-Teton National Forest have come to realize this fact and have been forced to waive seasonal restrictions to accommodate drillers, but Forest Service personnel in other areas still defend the widespread use of timing stipulations for mitigating wildlife impacts.

The Hebgen Lake Ranger District partially surrounds the town of West Yellowstone, Montana, where, as the EA mentions, virtually everyone directly or indirectly makes a living from tourism. Yet the EA casually dismisses the possible adverse effects of oil and gas development adjacent to this entrance to Yellowstone Park, concluding that:

"Oil and gas exploration and development activity in this area could have a wide range of adverse effects including noise, visual disruptions, undesirable odors and fumes, and increased traffic with large trucks and machinery. The offensiveness of the particular activity would depend to a large extent on the individual sensitivities of the individual recreationist and on the extent of whatever oil and gas development may result. Conversely, some recreationists may be more tolerant realizing that their recreation experience is linked to the availability of petroleum products."

A common problem with the current oil and gas leasing system is the dispersed responsibility for leasing among federal agencies, with leasing decisions frequently involving the Forest Service, the Bureau of Land Management, and the Minerals Management Service (MMS; formerly part of the U.S. Geological Survey — USGS). The Forest Service in the Hebgen Lake EA uses this dispersed responsibility to "pass the buck" for leasing lands under their jurisdiction adjacent to the Yellowstone Park boundary. Only possible impacts to the park's geothermal resources are considered, and even those impacts are summarily dismissed. A sampling of the impact analysis comments:

"People have expressed the concern that drilling for oil and gas in the Hebgen Lake area could disrupt the geothermal systems that feed the geysers in the park. This is unlikely for several reasons: First, it is highly improbable for geophysical reasons that an oil and gas reservoir would underlie any geothermal phenomenon. Therefore, petroleum geologists who encountered high subsurface heat during any drilling operations would be likely to cease operations . . .

"Development or utilization of a geothermal resource is not permitted under auspices of an oil and gas lease . . .

"Also, the USGS [now MMS] has the authority under NTL 6 [a lease stipulation] to require a termination of drilling if a geothermal pocket is encountered . . .

"It would be the responsibility of the USGS [now MMS] to conduct an environmental analysis to evaluate any risk to Yellowstone hydrothermal resources prior to approving operating plans or issuing permits to drill. In short, there is an abundance of federal review to ensure that any proposed development does not conflict with other federally administered resources, such as Yellowstone Park."

The Forest Service's attitude seems to have been "lease now, worry later." The above excerpts were included in the EA in response to a letter from the regional director of the National Park Service, expressing concern for protection of Yellowstone National Park resources.

## APPENDIX C.

# Recent Attempts to Evaluate the Impact of Oil and Gas Development on Wildlife Populations

Biologists with the Shoshone National Forest have attempted to evaluate the impacts of seismic testing on threatened and endangered species, such as the bald eagle and grizzly bear, which are found throughout much of the Greater Yellowstone area. In an environmental assessment released in 1982, the following possible impacts are considered:

(1) effects of concussion or noise levels from blasting;

(2) the effects of activities related to proximity (spatial requirements) of identified threatened and endangered species;

(3) effects of helicopter activity;

(4) effects of seismic camp locations and sanitation on grizzly behavior;

(5) magnitude and cumulative effects of seismic activities;

(6) variations of effects based on the timing of seismic operations; and

(7) effects of potential grizzly-human confrontations resulting from operations.

Once again, since few actual studies have been done on the impact of seismic exploration, the forest biologists were forced to base their recommendations for the control of seismic operations on educated assumptions. For the bald eagle, the biologists suggested the banning of seismic activities along certain river corridors, such as the South Fork of the Shoshone River, during the nesting season between March 1 to July 1. In other portions of the forest, seismic operations were recommended to be kept at least three miles away from any active bald eagle nests.

With the grizzly bear, three general assumptions concerning its behavior were made by the biologists:

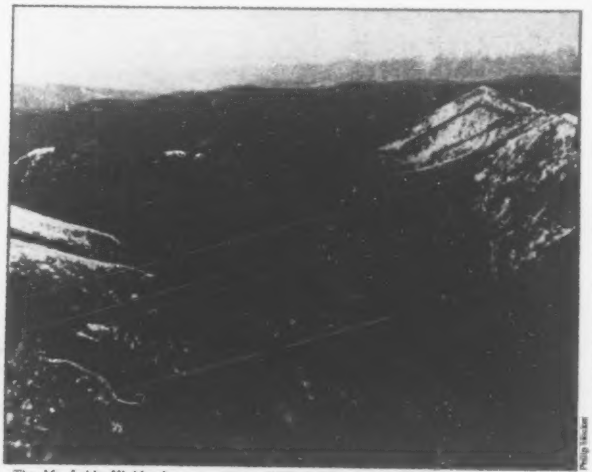
(1) Grizzlies are generally intolerant of human activity. Such disturbances would include noise from explosions, intense helicopter activity, and the increased human activity involved with shooting seismic lines. The greater the amount of activity, the more likely it becomes that any given bear will move out of the area where the activity is taking place.

(2) Continuous human activity has the potential to permanently remove the grizzly from that area.

(3) The concussion and/or noise level of explosions have the potential to disturb the grizzly within its den. Such disturbances could cause a bear to leave its den during a time when food sources are scarce during the winter months, and it would be difficult for the bear to locate or dig another den. It is estimated that any seismic blast within a two-mile radius of a den could cause a grizzly to leave, and the removal of the immediate disturbance is no guarantee that the bear will return.

The biologists' recommendations which followed from these assumptions were to ban seismic activity in grizzly bear Situation I habitat during the important pre- and post-denning feeding periods, and during the denning period itself. This left only a two-month period between July 15 and September 15 (during the prime summer tourist season) when the biologists felt that seismic testing could be permitted with minimal impacts on the bear. Even then, additional restrictions on helicopter flight corridors, heliport placement, and the timing of operations during daytime hours were placed on seismic crews.

Clearly, more study on the impacts of seismic activity on wildlife is needed. Unfortunately, the Forest Service chose to lease millions of acres of sensitive wildlife habitat in the Yellowstone region without first evaluating the possible consequences for wildlife.



*The Mt. Leidy Highlands, a sensitive wildlife habitat just south of Yellowstone Park is a battleground for oil and gas leasing.*

## APPENDIX D.

# The Law and Oil and Gas Leasing in National Forests

The role of the Forest Service in oil and gas leasing is defined by an interagency agreement with the Bureau of Land Management (BLM). The Secretary of the Interior, through the BLM, administers the 1920 Mineral Leasing Act (30 U.S.C. Sec. 181 et seq.); the Forest Service has no direct statutory authority over leasing on National Forest System lands (See 30 U.S.C. Sec. 226(a)). Pursuant to the interagency agreement, the Forest Service is responsible for preparing the environmental documentation required by the National Environmental Policy Act (NEPA) (42 U.S.C. Sec. 4321 et seq.). In turn, the agreement permits the Forest Service to provide the BLM with "advisory, nonbinding recommendations" regarding leasing (see. 49 Fed. Reg. 37440-42, September 24, 1984). The BLM may disregard those recommendations, however, in making its leasing decisions.

Even given its limited role in oil and gas leasing, the Forest Service has failed to comply with legal standards. Generally speaking, these shortcomings may be grouped into three categories: inadequate compliance with NEPA; unwillingness to recommend not to lease; and failure to integrate leasing recommendations into land-use plans prepared pursuant to the National Forest Management Act. (16 U.S.C. Sec. 1600 et seq.).

## Inadequate Consideration of NEPA

Section 102(2)(C) of NEPA requires that when an agency proposes a major federal action that may have a significant effect on the environment, an environmental statement describing the consequences of the proposal, and its alternatives, must be prepared as a basis for administrative decisionmaking (42 U.S.C. Sec. 4332(2)(C)). The Forest Service has consistently failed to prepare such statements in connection with oil and gas leasing. Instead, the agency has relied upon the inclusion of lease stipulations intended to mitigate the environmental effects of roadbuilding and drilling, and avoided preparation of impact statements through a routine finding that "no significant environmental effects" would result from issuing leases. This approach suffers from two flaws. First, stipulations have often been mechanically applied without adequate assurances that the resultant protections are actually effective. For example, the common reliance on no-surface-occupancy (NSO) stipulations, as pointed out in *Bob Marshall Alliance v. Watt* (CV-82-015-GF, May 27, 1986), should not be used to circumvent the requirement of preparing an EIS. Furthermore, this reliance on NSO stipulations over broad areas as a substitute for thorough environmental analysis can render commercial extraction of the leased mineral resource impossible, setting the stage for a subsequent challenge to such stipulations by the lessee. (Cf. *Rocky Mountain Oil & Gas Assn. v. Andrus*, 500 F.Supp. 1338 (D. Wyo. 1980); rev'd on other grounds sub. nom. *Rocky Mountain Oil & Gas Assn. v. Watt*, 696 F.2d 734 (10th Cir. 1980)).

The second flaw concerns the Forest Service practice of making the finding of no significant environmental impact when the recommended lease would convey to the operator a right to conduct activities that could result in serious ecological consequences. As the Court of Appeals for the District of Columbia has explained in *Sierra Club v. Peterson*, (717 F.2d 1409, 1415 (D.C. Cir. 1983)), preparation of an environmental statement is necessary in connection with such a lease unless the stipulations reserve to the government authority to "preclude all surface disturbing activities." The Forest Service routinely fails to recommend giving the agency full control over mineral development stipulations, yet does not prepare the necessary environmental statement. The Forest Service has steadfastly avoided any recognition that hundreds and probably thousands of oil and gas leases have been issued for National Forest lands in violation of NEPA under *Peterson*. No remedy for any illegally issued leases has been implemented, despite the government's private admission in litigation brought to challenge NEPA compliance that some remedy is necessary. As a result of the Forest Service's failure to correct the inadequacies of its leasing procedures, it continues to lose in court (see, for example, *Conner v. Burford*, 605 F.Supp. 107 (D. Mont. 1985), appeal docketed).

## Lack of Recognition of Authority to Not Issue Leases

In addition to its NEPA failings, the Forest Service has adopted a leasing policy that fails to acknowledge the authority of the Secretary of the Interior under the Mineral Leasing Act not to issue leases. That authority is separate from the power of withdrawal governed by Section 204 of the Federal Land Policy & Management Act (43 U.S.C. Sec. 1714). The Mineral Leasing Act permits the Secretary to reject lease offers, without withdrawal, if he determines that other land values outweigh the mineral resource (see Richard K. Todd, 68 I.D. 291, 295 (1961); *Duesing v. Udall*, 350 F.2d 748 (D.C. Cir. 1965); *Learned v. Watt*, 528 F.Supp. 980 (D. Wyo. 1981). In fact, *Bob Marshall v. Watt* holds that the lack of meaningful consideration of a no-leasing alternative directly violates NEPA. Rather than recommend exercise of that authority, the Forest Service has elected to pursue a policy that avoids saying "no" out of a fear that a no-lease decision cannot be made in anything less than extreme circumstances. In some instances, the Forest Service has unsuccessfully attempted to simply not respond to lease offers. *(Mountain State Legal Foundation v. Andrus*, 499 F. Supp. 343 (D. Wyo. 1980)).

Not surprisingly, this misreading of the Mineral Leasing Act has resulted in an agency commitment to leasing as the overwhelming option of choice. As noted below, this lease-by-lease policy has also resulted in microscopic rather than macroscopic resource management.

## Inadequate Integration of Minerals in Forest Plans

The final major flaw concerns the Forest Service's failure to integrate mineral leasing decisionmaking into forest planning under the National Forest Management Act (NFMA). NFMA obligates the agency to consider mineral resources as part of the Forest Service's land management functions (see 36 C.F.R. Secs. 2129.1(b)(2) and 219.22). The regulations that implement NFMA specifically directed that forest planning shall take cognizance of the probable occurrence of such minerals as oil and gas (36 C.F.R. 219.22(c)), the potential for development of those minerals (36 C.F.R. 219.22(d)), the need for protective withdrawals (id.), as well as evaluate the availability and suitability of national forest lands for mineral management (36 C.F.R. Sec. 219.1(b)). The resulting plan shall "guide all natural resource management activities" and "determine resource management practices [and] levels of resource production and management" (36 C.F.R. Sec. 219.1(b)).

These overlapping duties dictate a change from the reactive, ad hoc approach to oil and gas leasing historically adopted by the Forest Service. NFMA planning requires instead affirmative determinations by the agency of what areas may contain oil or gas, which areas are suitable for development, what standards will determine leasing recommendations, and whether certain national forest lands should be off-limits to oil and gas development. Moreover, NFMA requires that those determinations be made in a planning process that simultaneously considers other forest resources, including wildlife, recreation, and wilderness. Although a forest plan is to become the determinant of leasing recommendations, very few current forest plans are adequate for that purpose. Most mention leasing only in generalities, reserving any specific standards or guidelines for eventual lease-by-lease analysis. This practice, particularly when combined with the agency's restrictive view of its authority to recommend against leasing, reduces oil and gas minerals management to merely the selection of boilerplate lease stipulations and avoids the Forest Service's duty to ensure that development takes place only where it is appropriate.

For the most part, each of these three flaws is the result of an administrative reluctance to devote the time and resources necessary for informed decisionmaking about public lands.

Appendix D was written by William S. Curtiss, staff attorney, Sierra Club Legal Defense Fund.

Photo courtesy of Great Bear Foundation

*Visitors to the Greater Yellowstone Region can still thrill at the sight of fresh grizzly bear tracks in the mud and know they are in a true wilderness. But if further human encroachments, including oil and gas development, are allowed in the Great Bear's critical habitat grizzlies may become just a memory.*